The Blackwater NWR Inundation Model
Rising Sea Level on a Low-lying Coast:
Land Use Planning for Wetlands

- An Integrated Science Team Product of the U.S. Geological Survey:

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Curt Larsen GD	Dan Kroes
Tom Yanosky WRD	Jim Lynch

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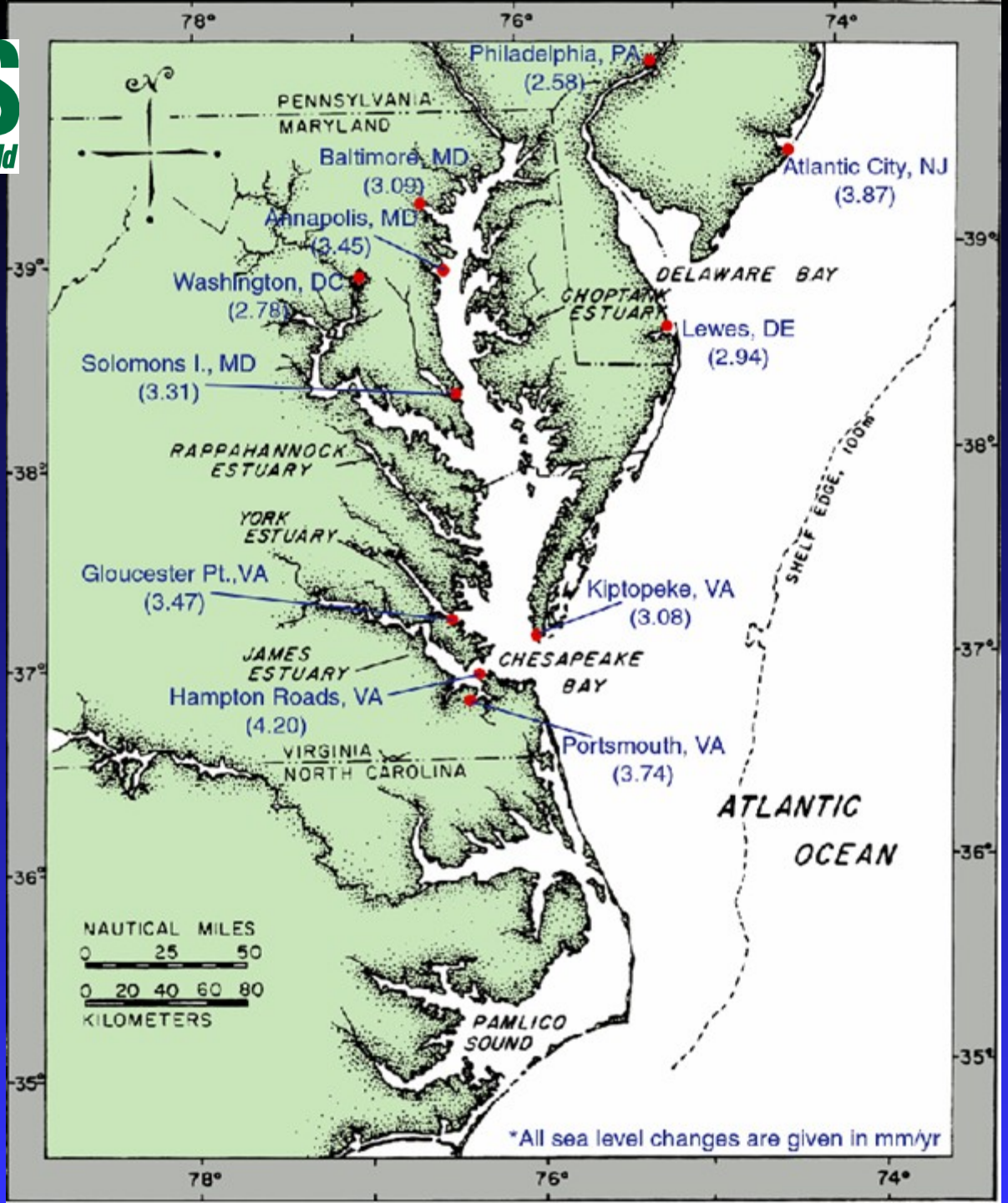

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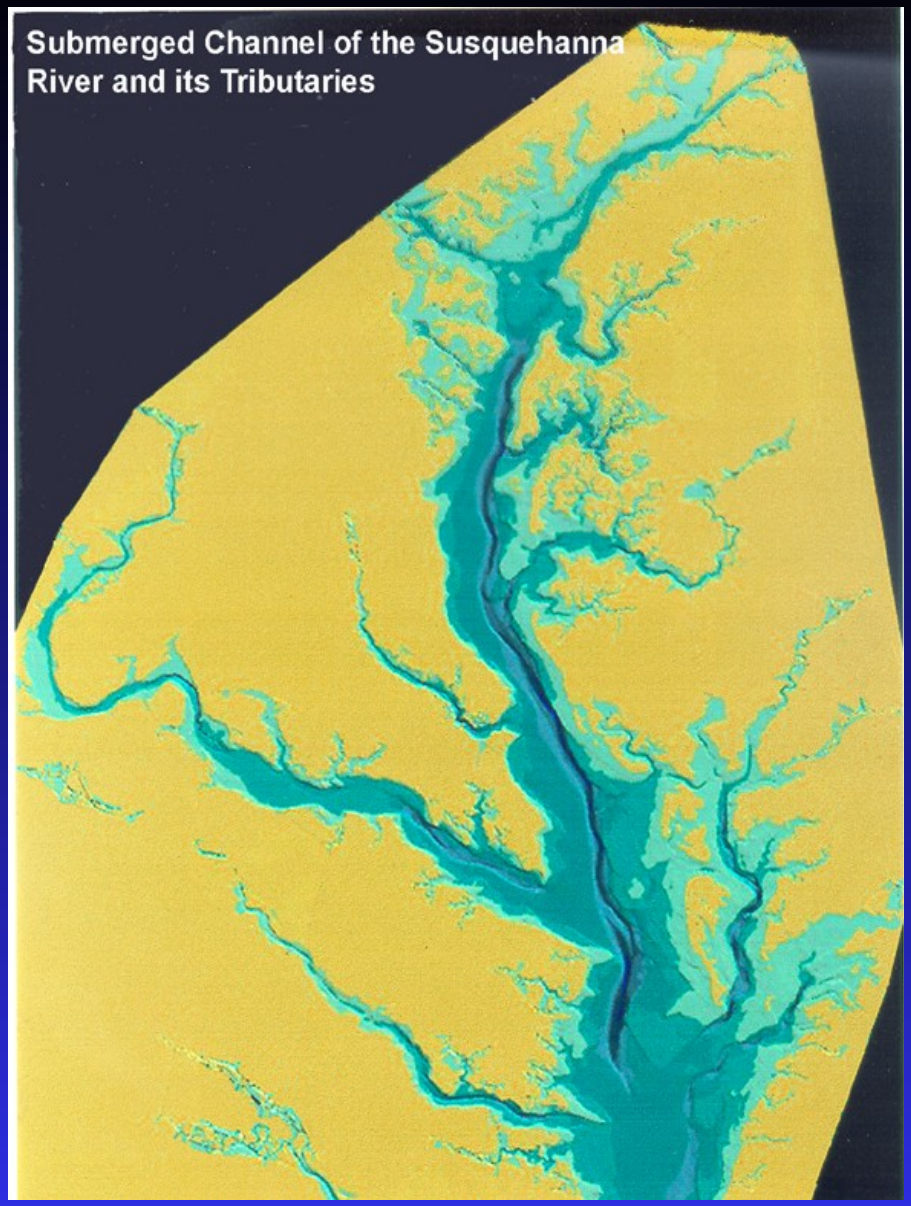
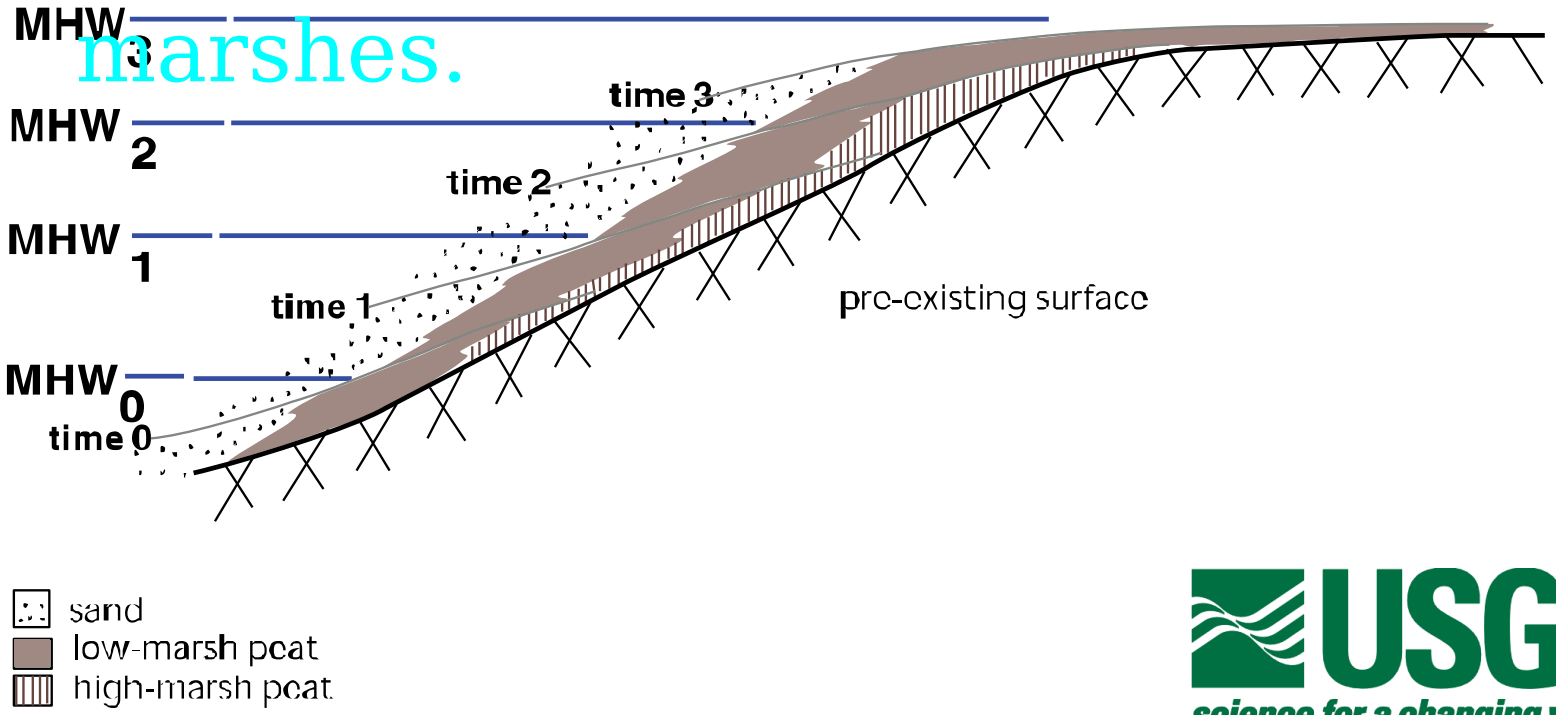


Maryland's Eastern Shore-salt marshes have developed as a function of topography. Low relief land areas gave rise of broad marshes.



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Blackwater NWR and Sea Level

- The Blackwater NWR has become an international example of “wetland loss” resulting from rising sea level.
- Sea level rise is progressively inundating a lowland surface formed at the last time sea level was high—ca. 125,000 years ago.
- In 1877, the area was mapped as forest.
- This is how it looks today.

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BLACKWATER NATIONAL
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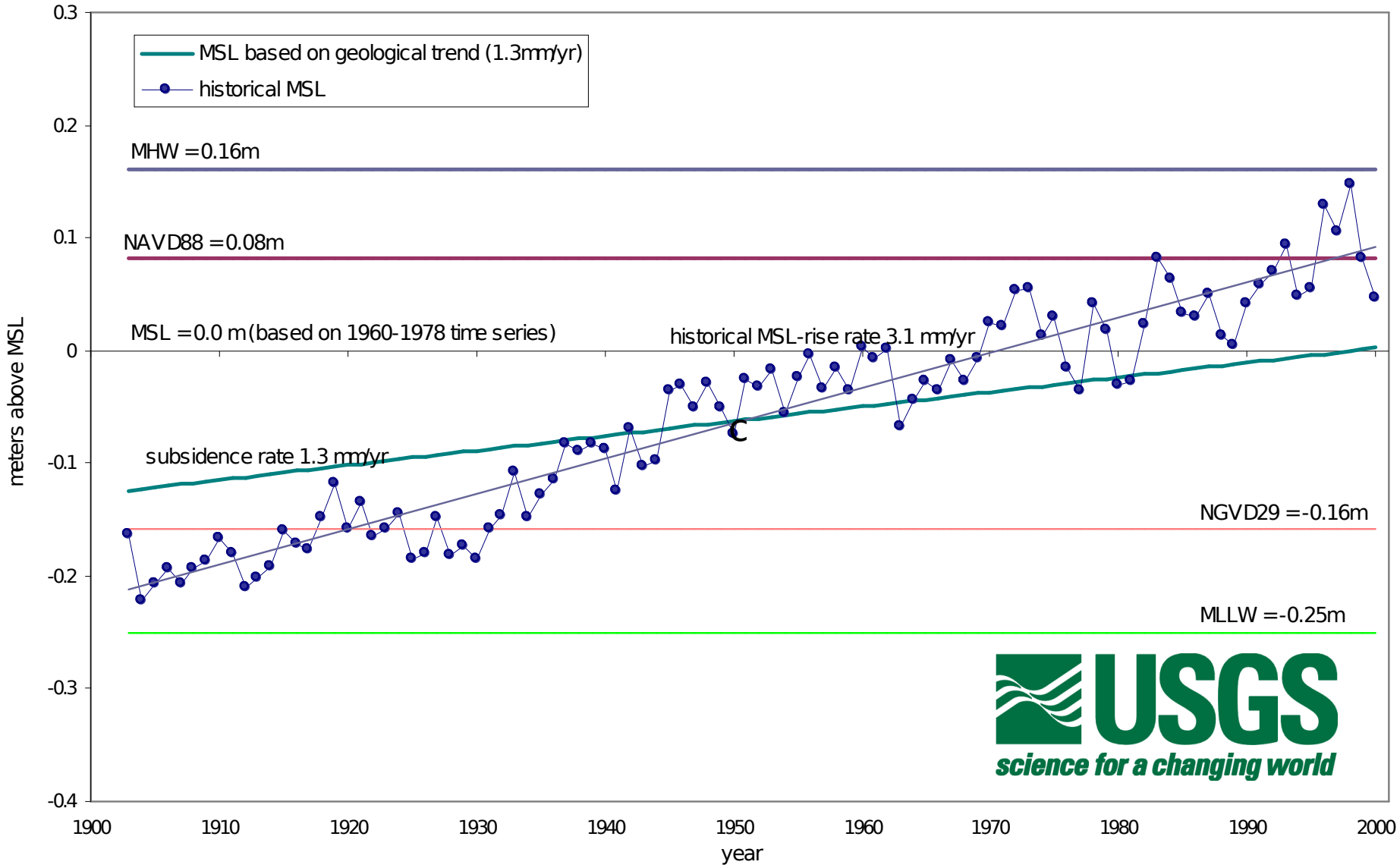
Relative mean sea level trend for Chesapeake Bay - geological trend vs historical values (relative to present MSL)



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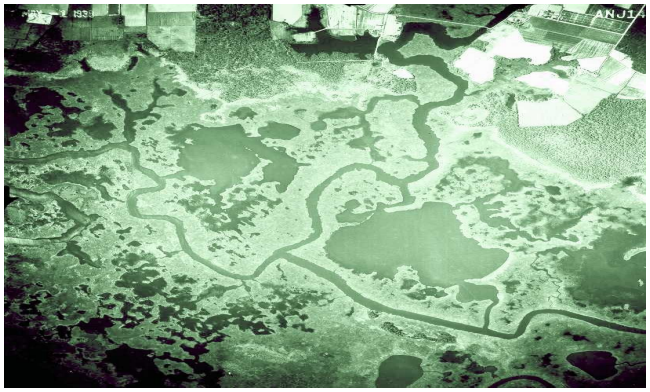
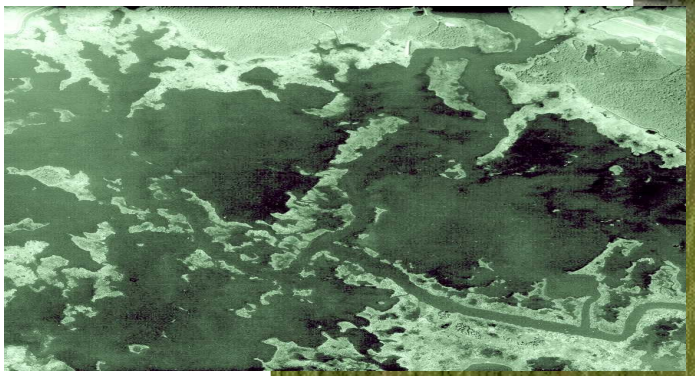
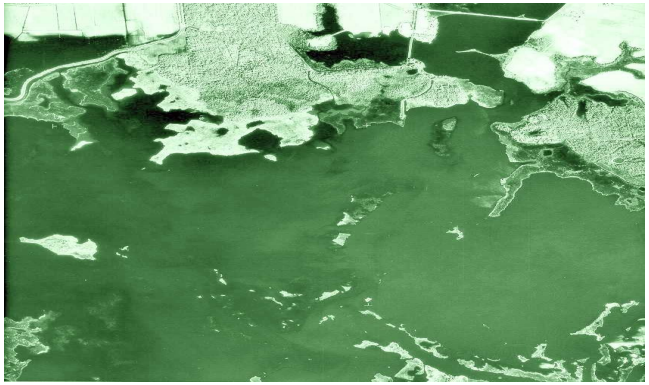
The Disappearing Marsh

The Confluence of the Blackwater and Little Blackwater Rivers show the steady erosion of the marsh. The marsh breached and eroded from the inside out, slowly connecting the natural ponds into a massive lake. Today, the former marsh is barely recognizable.







1989--discreet features have disappeared and severe marsh loss is evident.

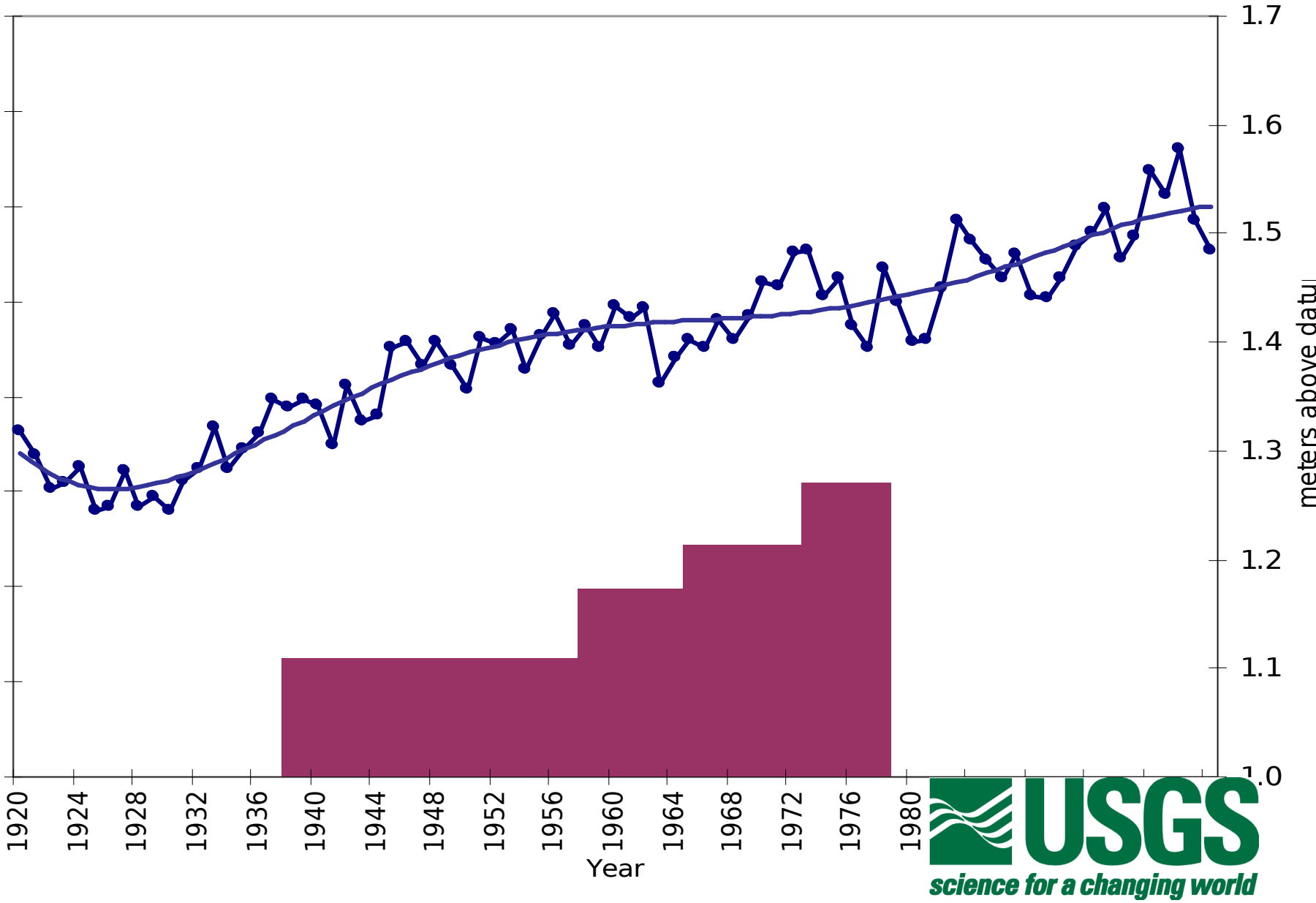
nds, integrity of the channels
mised
rsh loss is evident.

oximately 8000 acres
pproximately 130 acres

Blackwater is being Submerged

- An explanation is that salt marshes grow upward with rising sea level provided sediment is continuously deposited on their surfaces.
- Blackwater has no source of incoming sediment other than the adjacent uplands which provide little. Thus, it is being drowned.
- Inundation of a preexisting land surface is the dominant natural process affecting the NWR.
- But, recall that Blackwater didn't become a marsh until the 20th century.

Perceived Wetland Loss (Blackwater National Wildlife Refuge)



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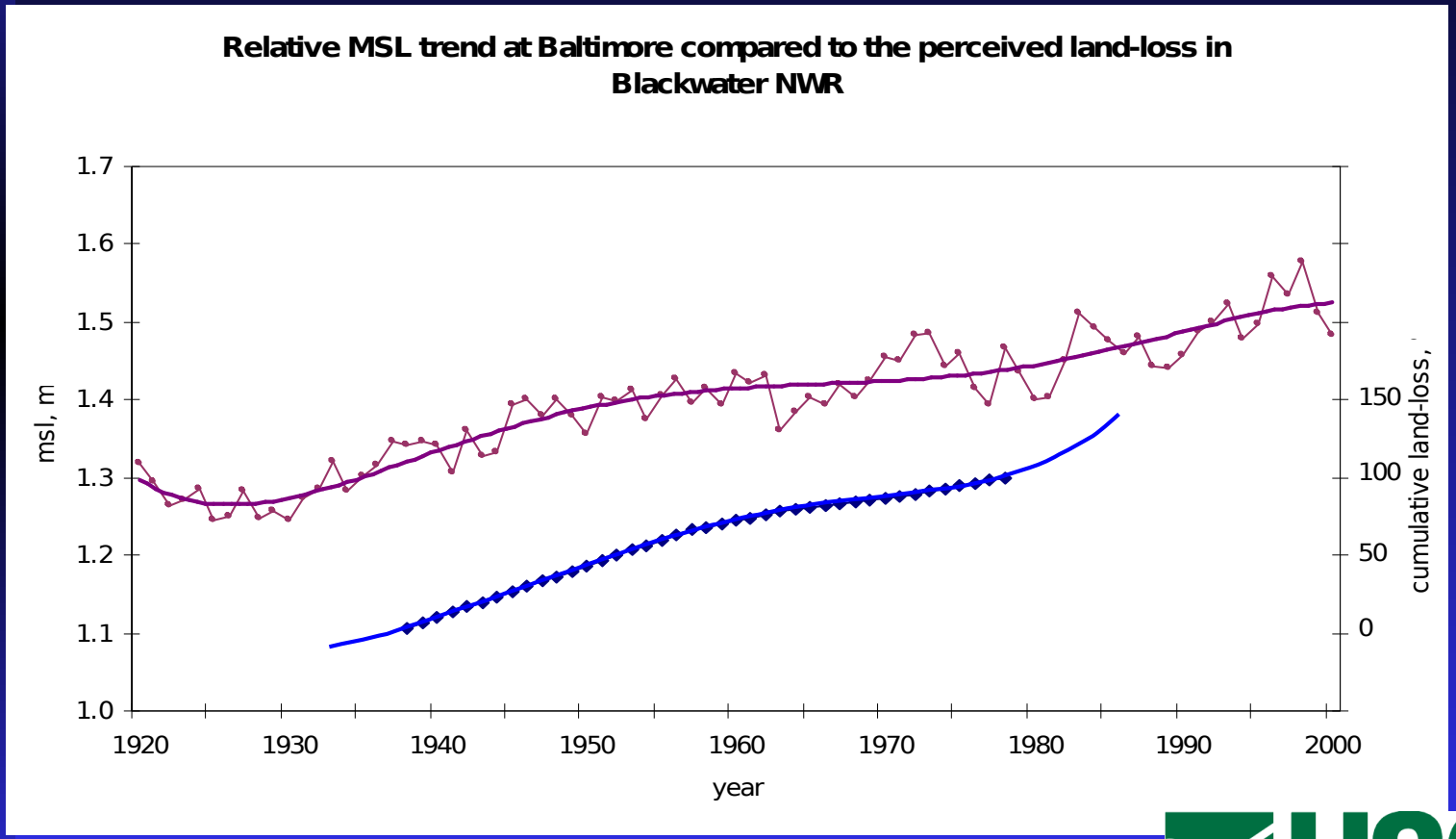
Cumulative expansion of open water (land loss) at Blackwater



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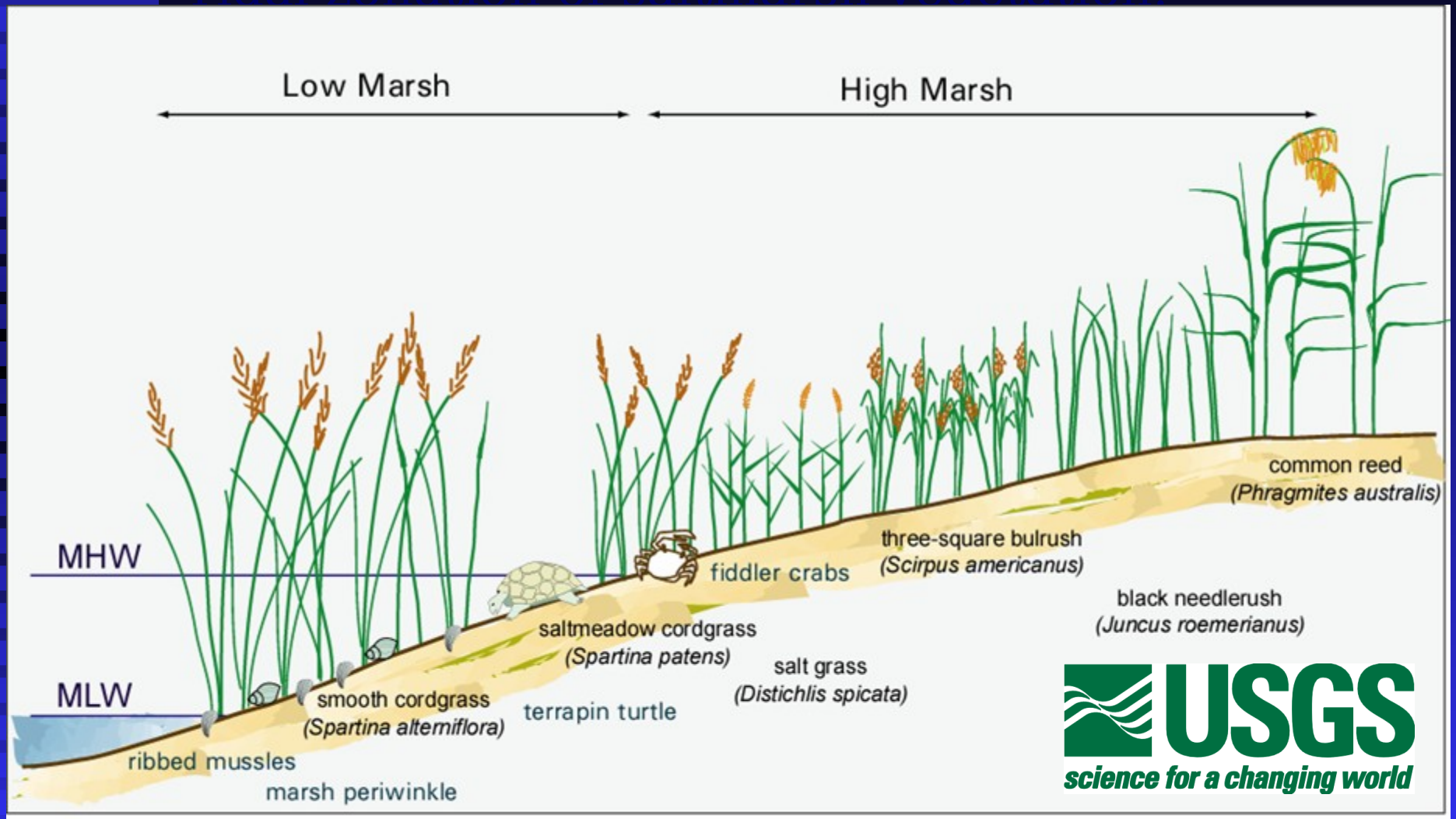
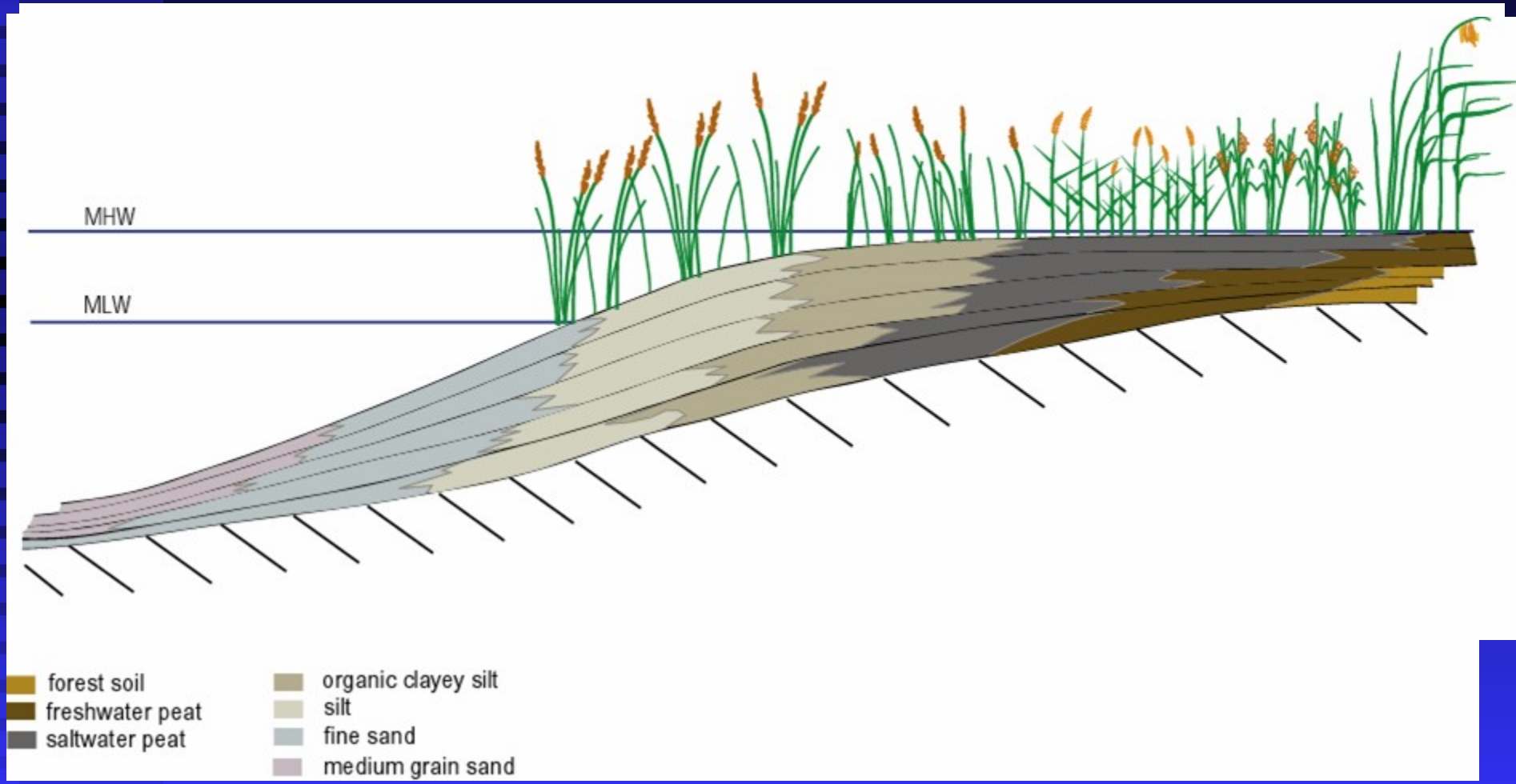
Tidal zonation of saltmarsh vegetation



High Marsh- Low Marsh sediment accumulation under rising sea level



Not to scale

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Sea Level Inundation Model for Blackwater NWR 2002-2100

- LIDAR Imagery flown March 25, 2002.
- Contour Interval 30 cm
- Datum NAVD 88.
- Tidal range at Fishing Bay:
- 76 cm between MHW and MLW
- 92 cm between Spring Tides.

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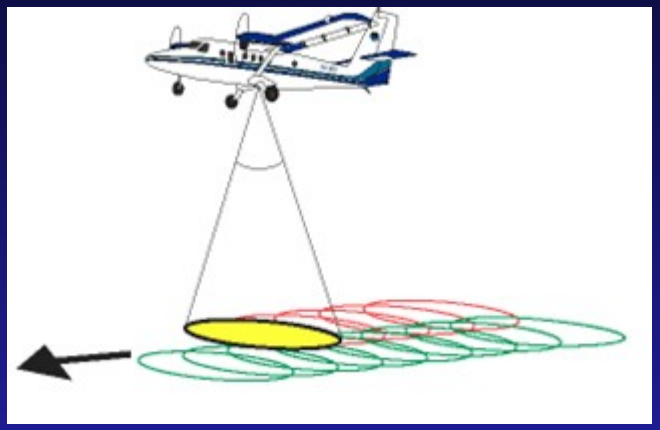
LIght Detection And Ranging



- Airborne scanning laser rangefinder
- Differential GPS
- Inertial Navigation System

30,000 points per second at ~15 cm accuracy

- $400–$1000/mi^2, 10^6 points/mi^2, or 0.04–0.1 cents/point

Extensive filtering to remove tree canopy (virtual defor-estation)

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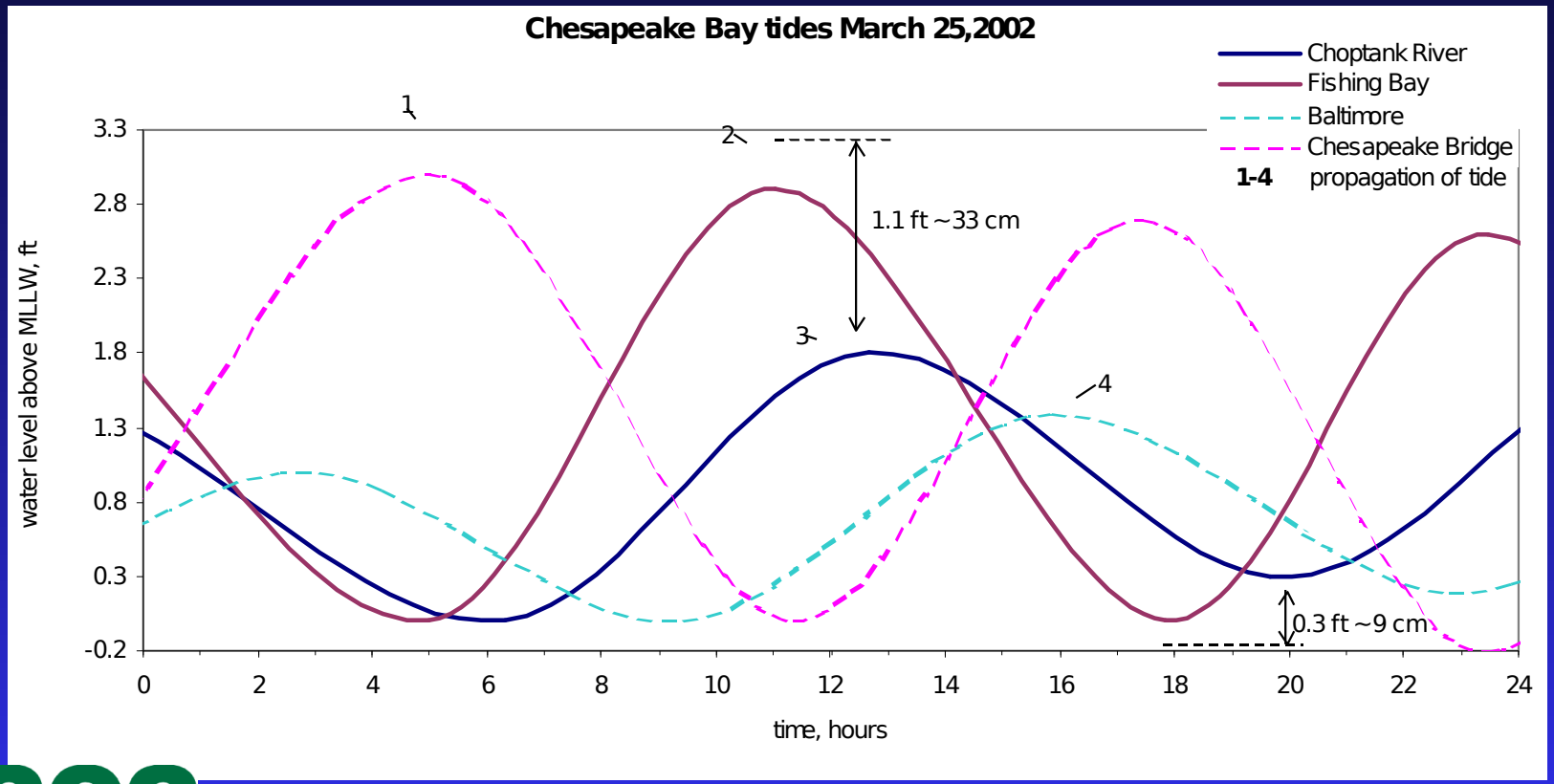
Tides the day of the Survey



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The Business as Usual Scenario

- The long term trend of sea level rise will continue at the current rate of 3.1 mm/year.
- Blackwater NWR water levels will be most affected by the tidal range in Fishing Bay and transmitted upstream along the Blackwater River.

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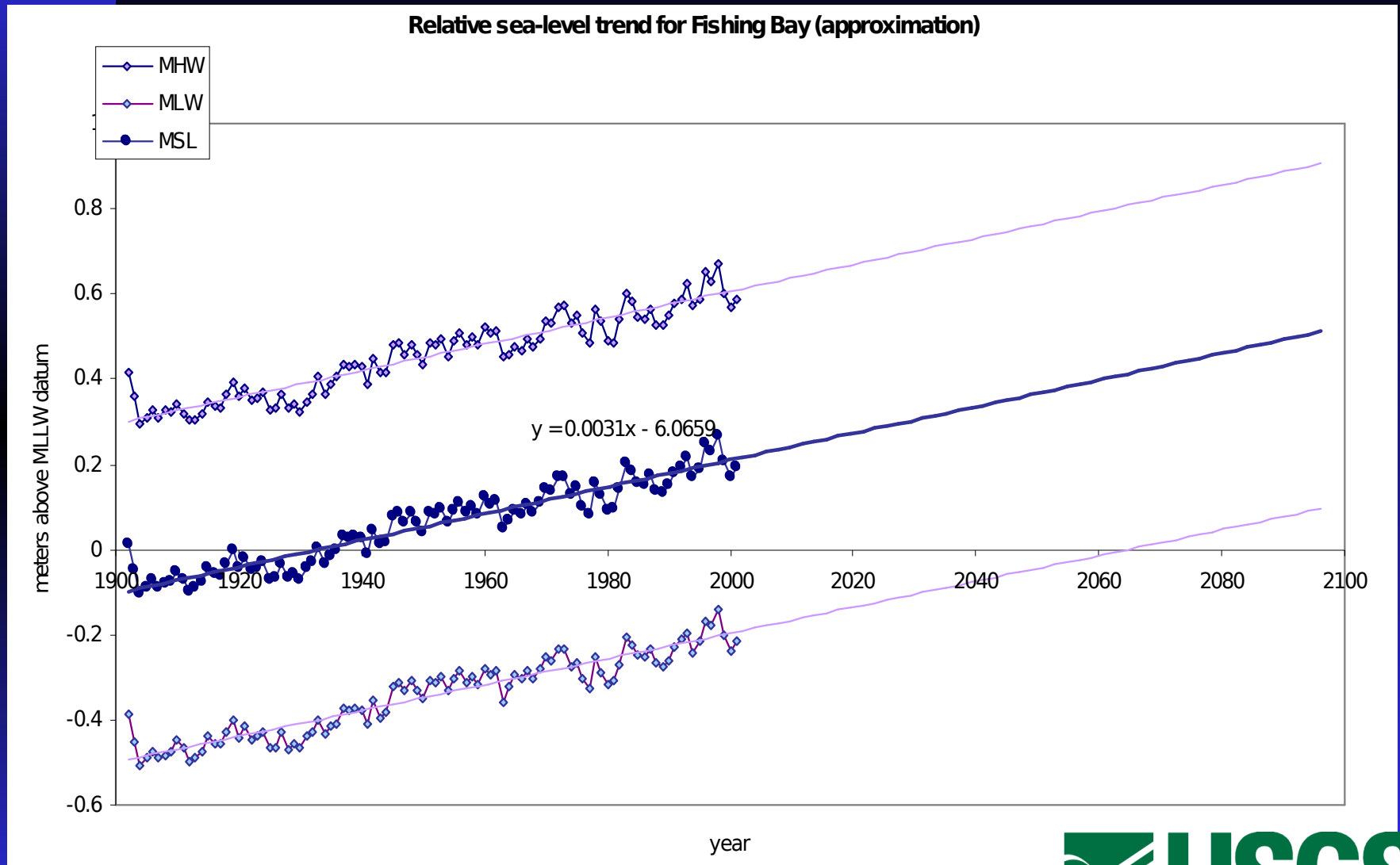

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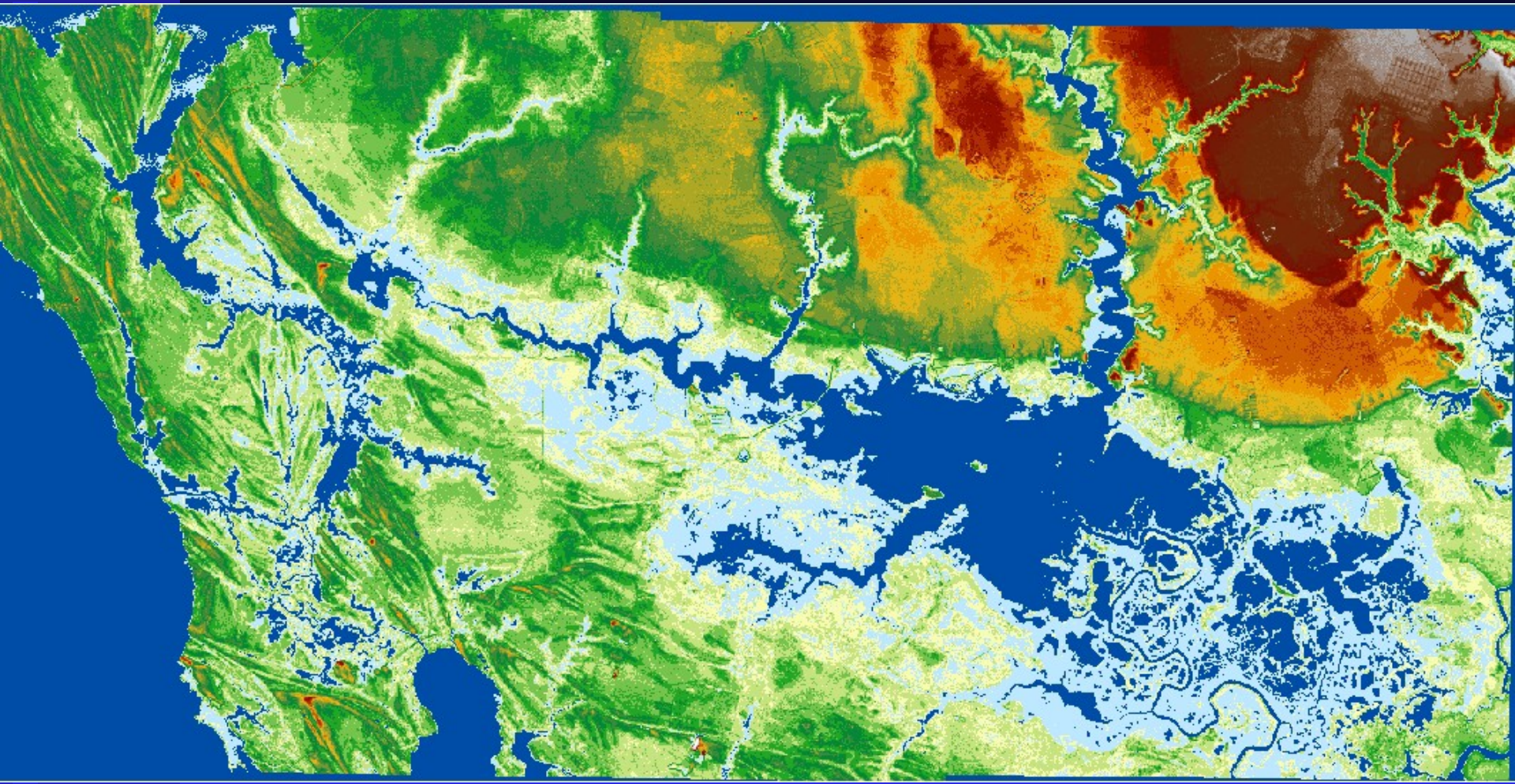
Blackwater National Wildlife Refuge Area, 2002

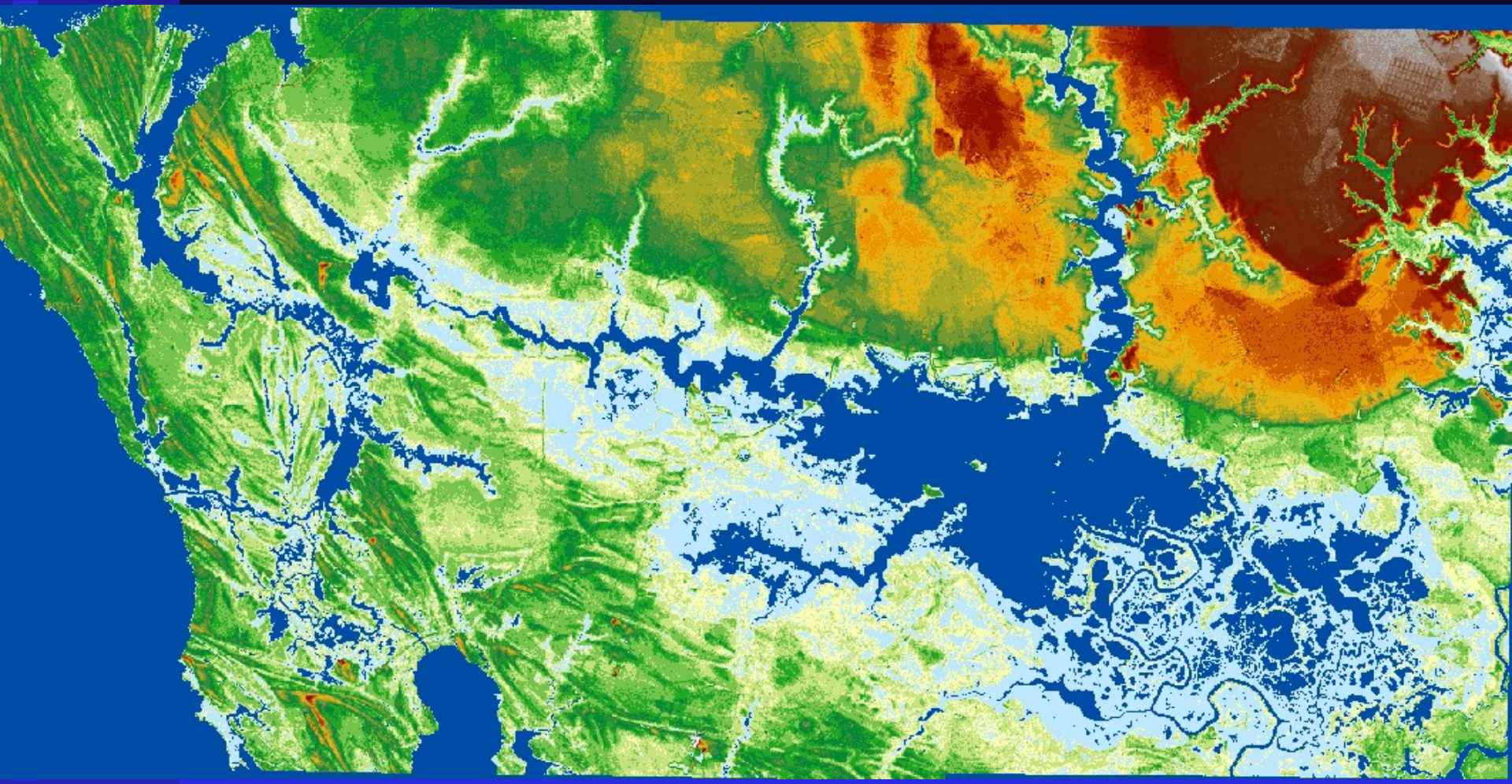


Open water

Intertidal marsh

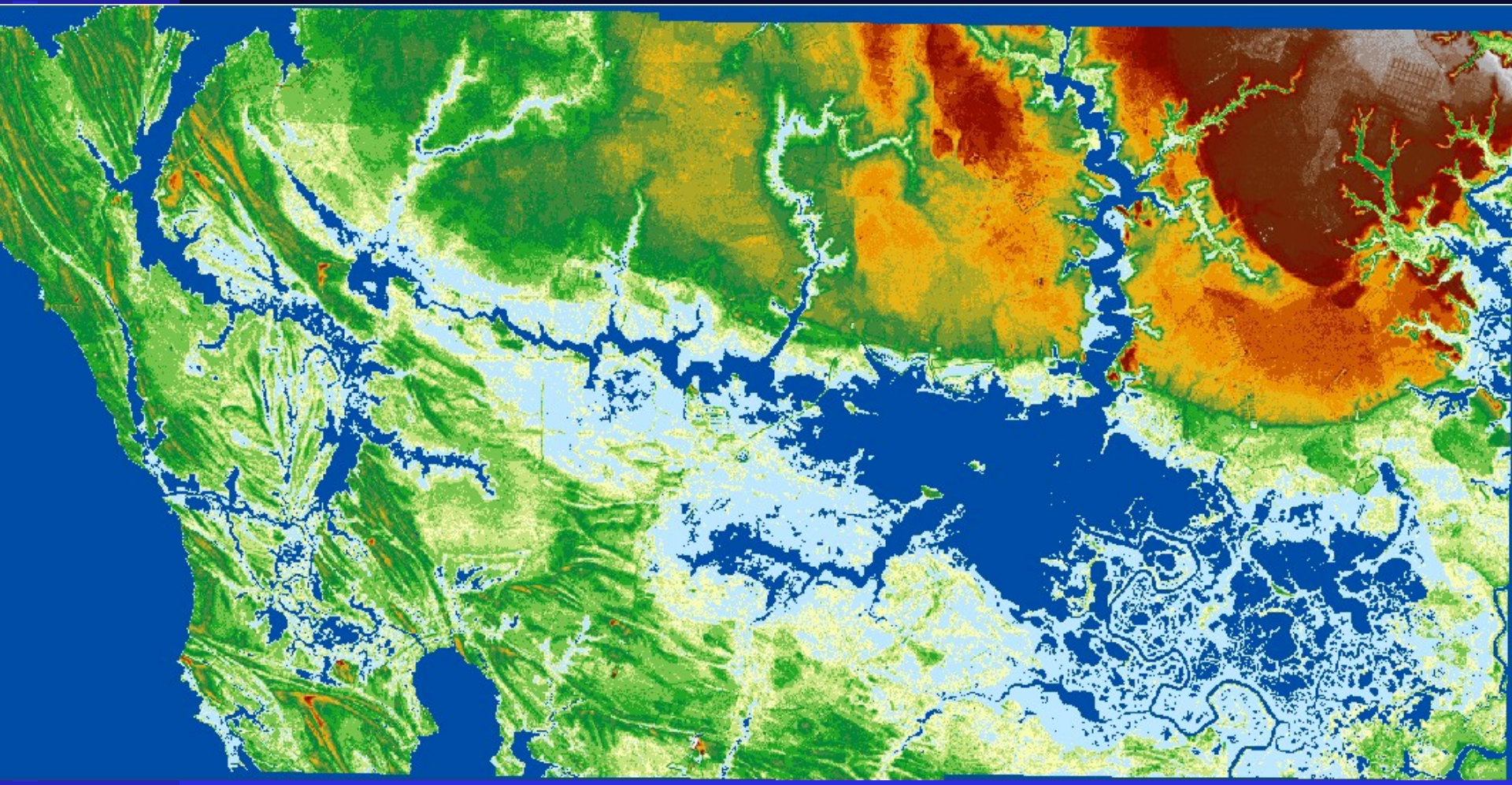
High marsh

Blackwater National Wildlife Refuge Area, 2010 (3 mm/yr rise)



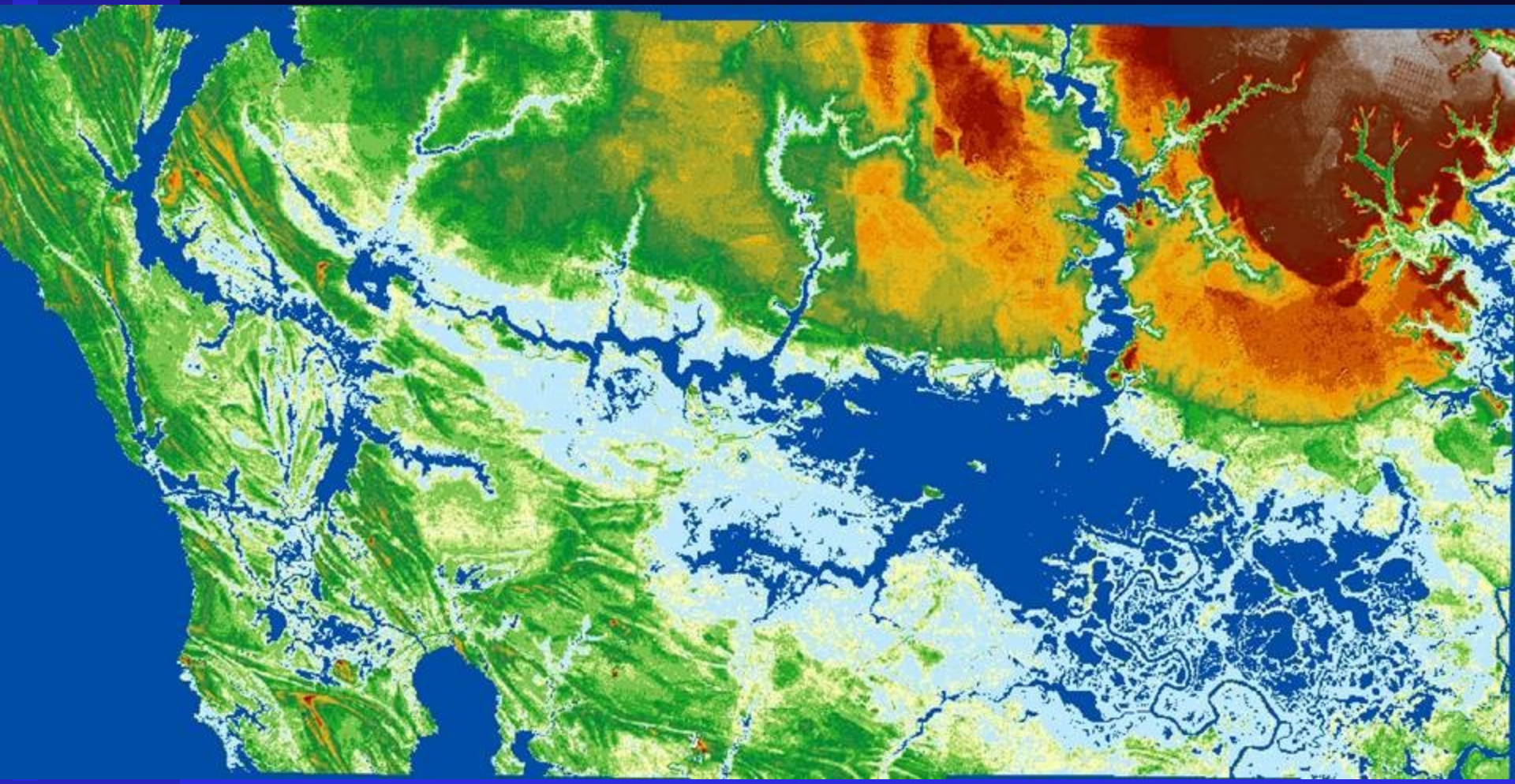
Open water Intertidal marsh High marsh

Blackwater National Wildlife Refuge Area, 2020 (3 mm/yr rise)



Open water Intertidal marsh High marsh

Blackwater National Wildlife Refuge Area, 2030 (3 mm/yr rise)

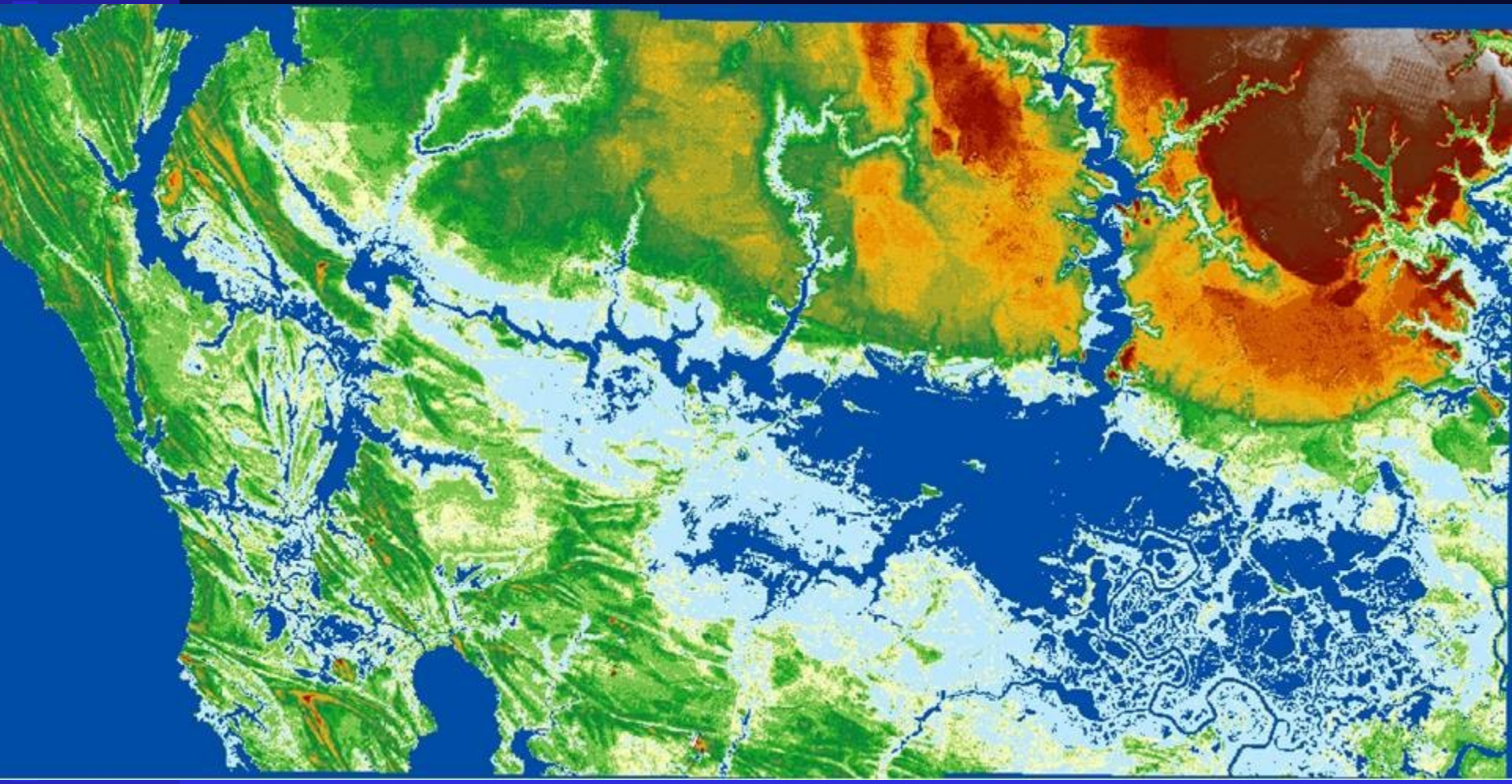


Open water

Intertidal marsh

High marsh

Blackwater National Wildlife Refuge Area, 2040 (3 mm/yr rise)

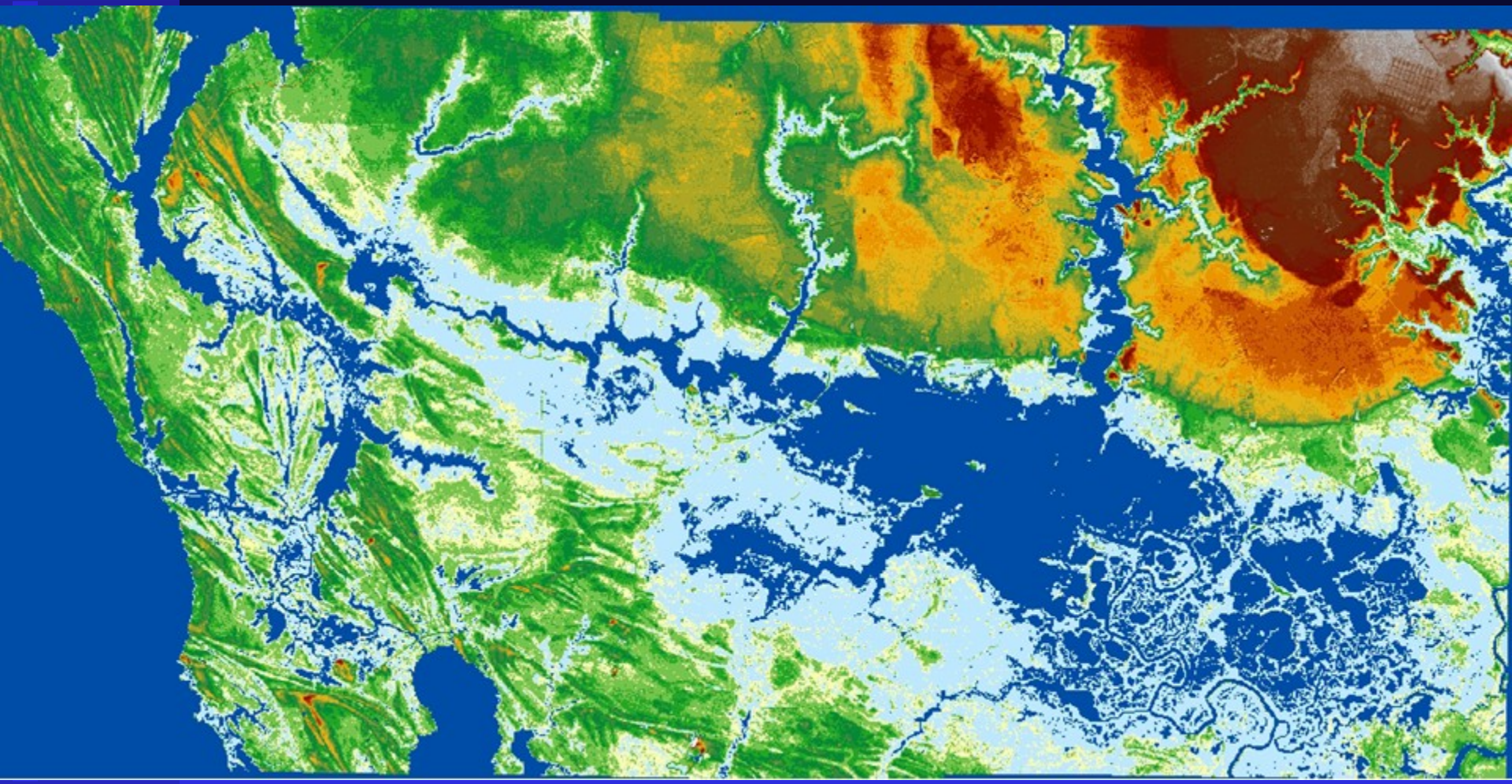


Open water

Intertidal marsh

High marsh

Blackwater National Wildlife Refuge Area, 2050 (3 mm/yr rise)

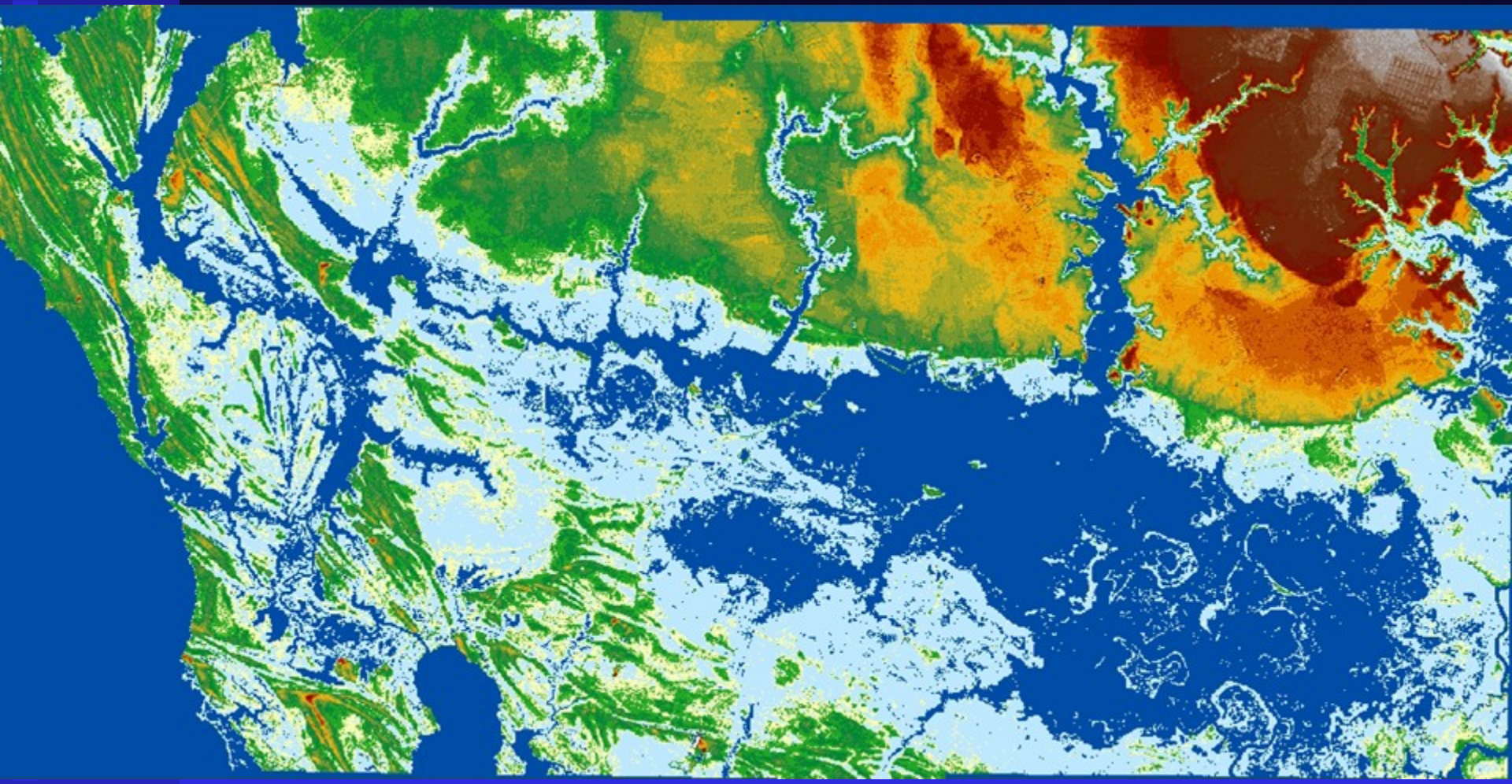


Open water

Intertidal marsh

High marsh

Blackwater National Wildlife Refuge Area, 2100 (3 mm/yr rise)

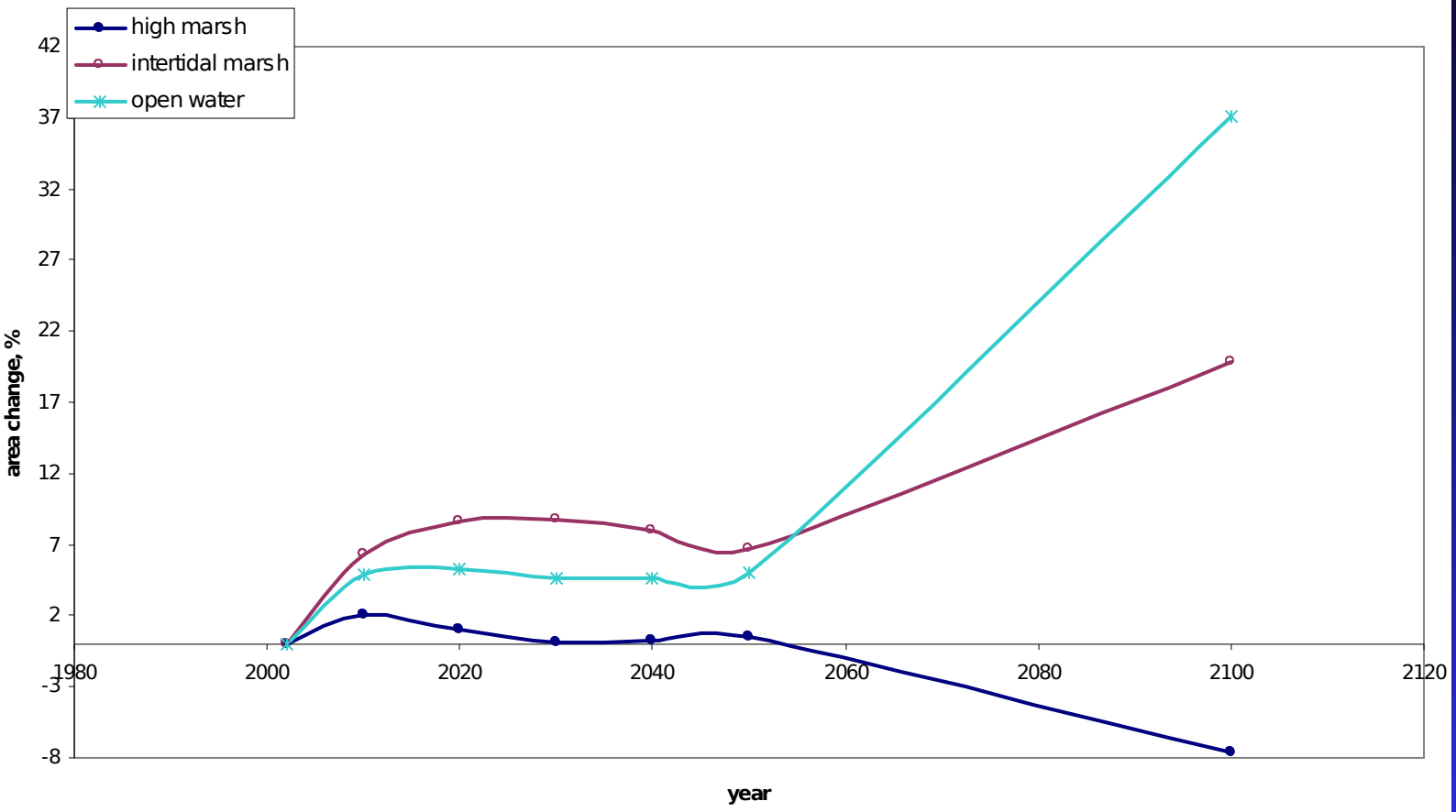


Open water

Intertidal marsh

High marsh

Blackwater NWR: projected changes in areas occupied by different types of marsh in 2002-2100 under constant sea level rise (3 mm/yr)



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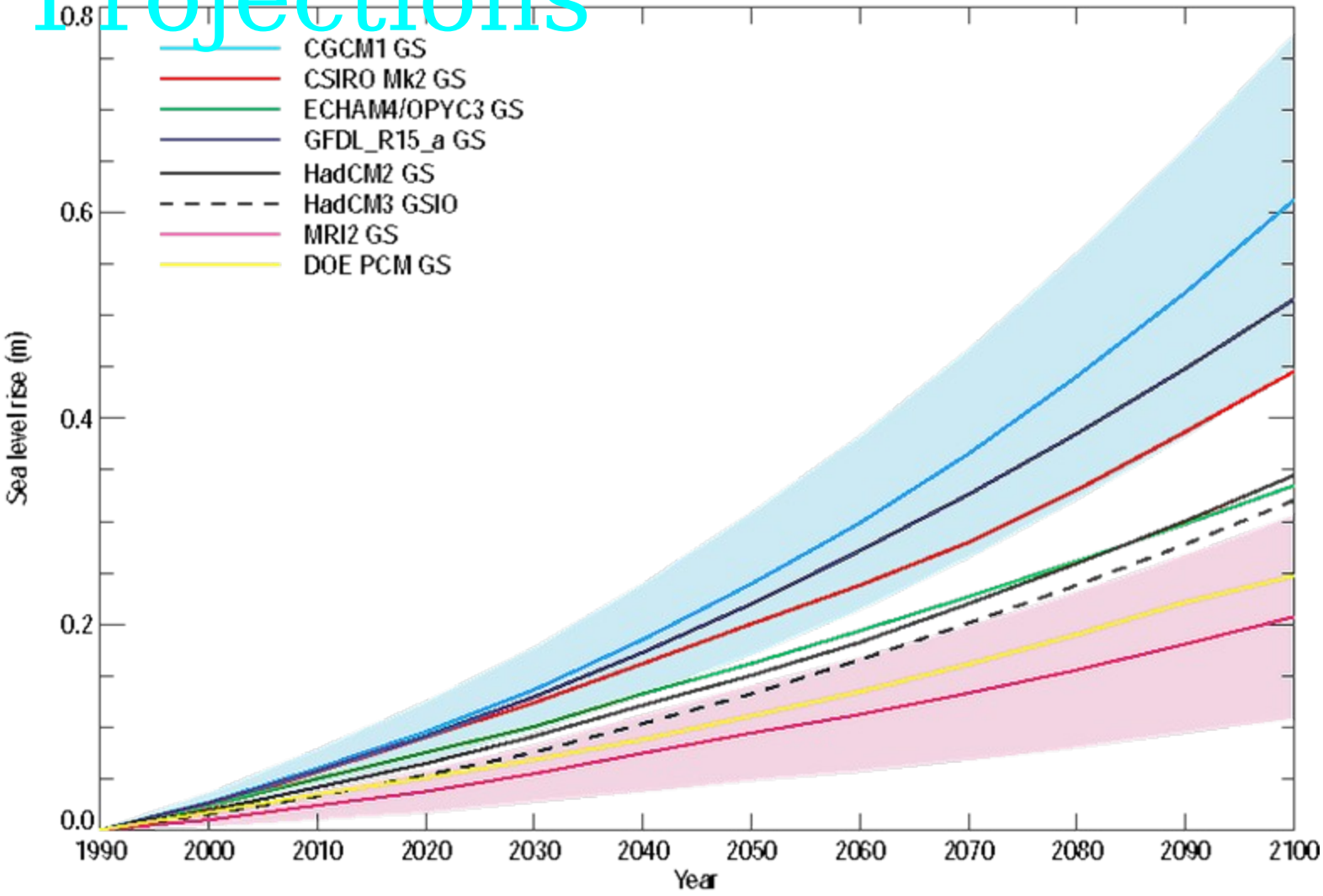
What does this say?

- First, the increase in the area of open water is relatively constant until about 2050 when open water shows a marked increase. This is due to topography.
- Inter tidal marsh area increases continually in keeping with the open water. It expands after 2050.
- High marsh area is relatively constant until 2050 then decreases sharply as low-lying land areas are inundated. This too, is a function of topography.
- In short, sea level overtops the existing landforms after 2050 and high marsh begins a major decline.

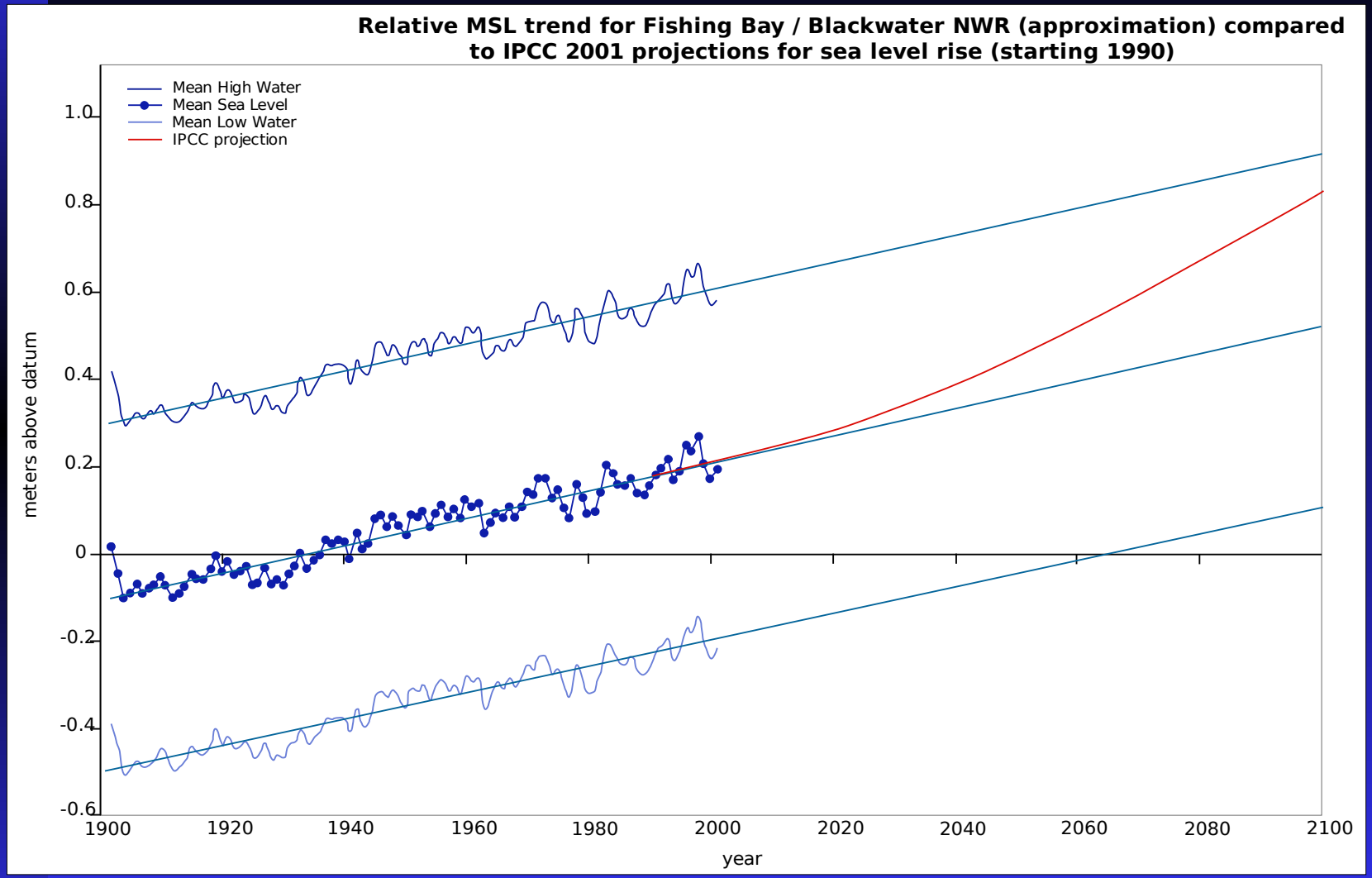
The Global Warming Scenario

IPCC (2001) Projects an increased rate of Sea Level Rise due to increased “Greenhouse gases” added to the

IPCC Sea Level Projections



Sea Level Scenario for IPCC 2001



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In Short:

- If global sea level rises at an accelerating rate, as suggested by IPCC projections, the rate of inundation at Blackwater will be much more rapid.
- The rate of rise shown here is an average of the various IPCC models and is thus very conservative (ie. It isn't a worst case).

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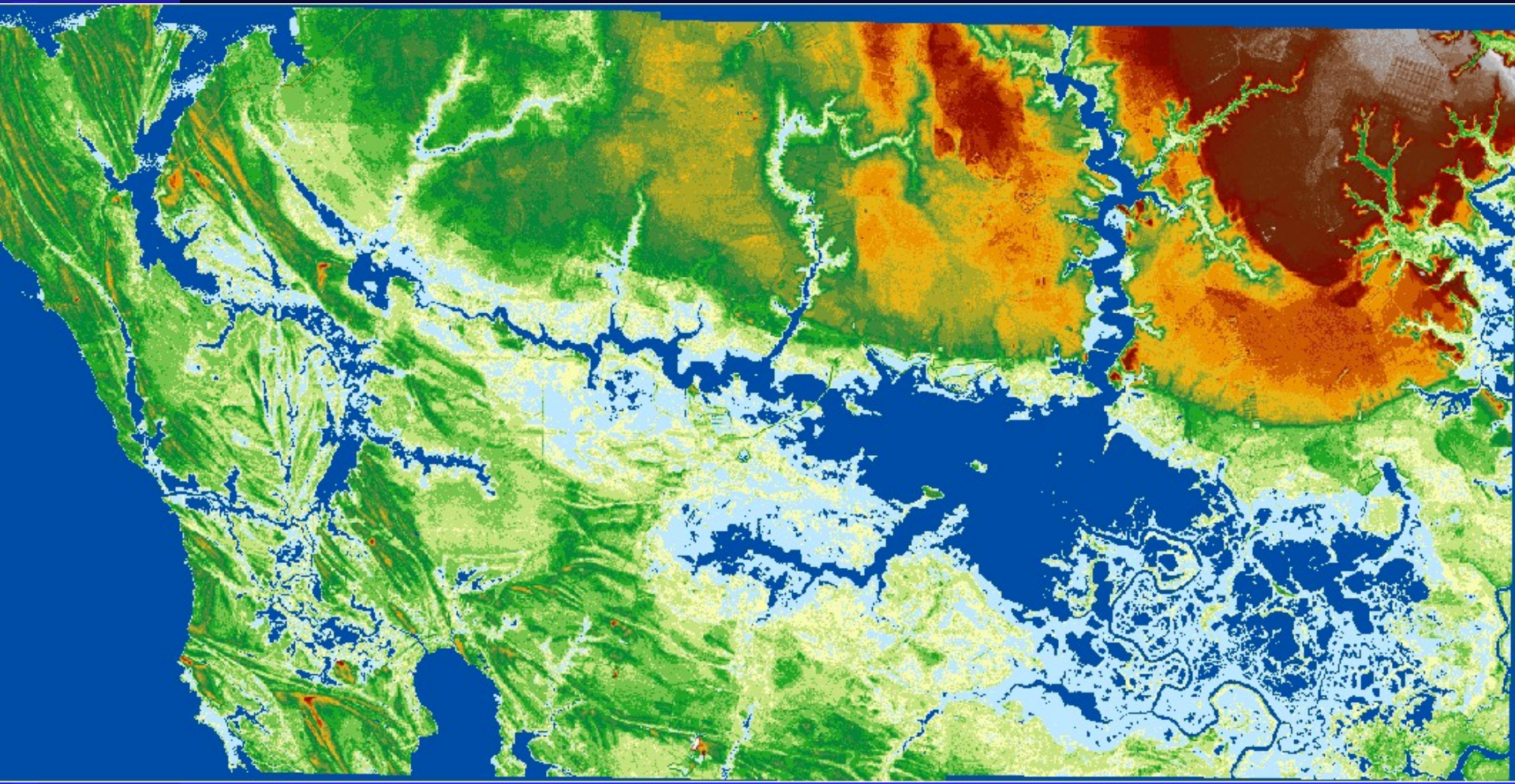
Blackwater National Wildlife Refuge Area, 2002

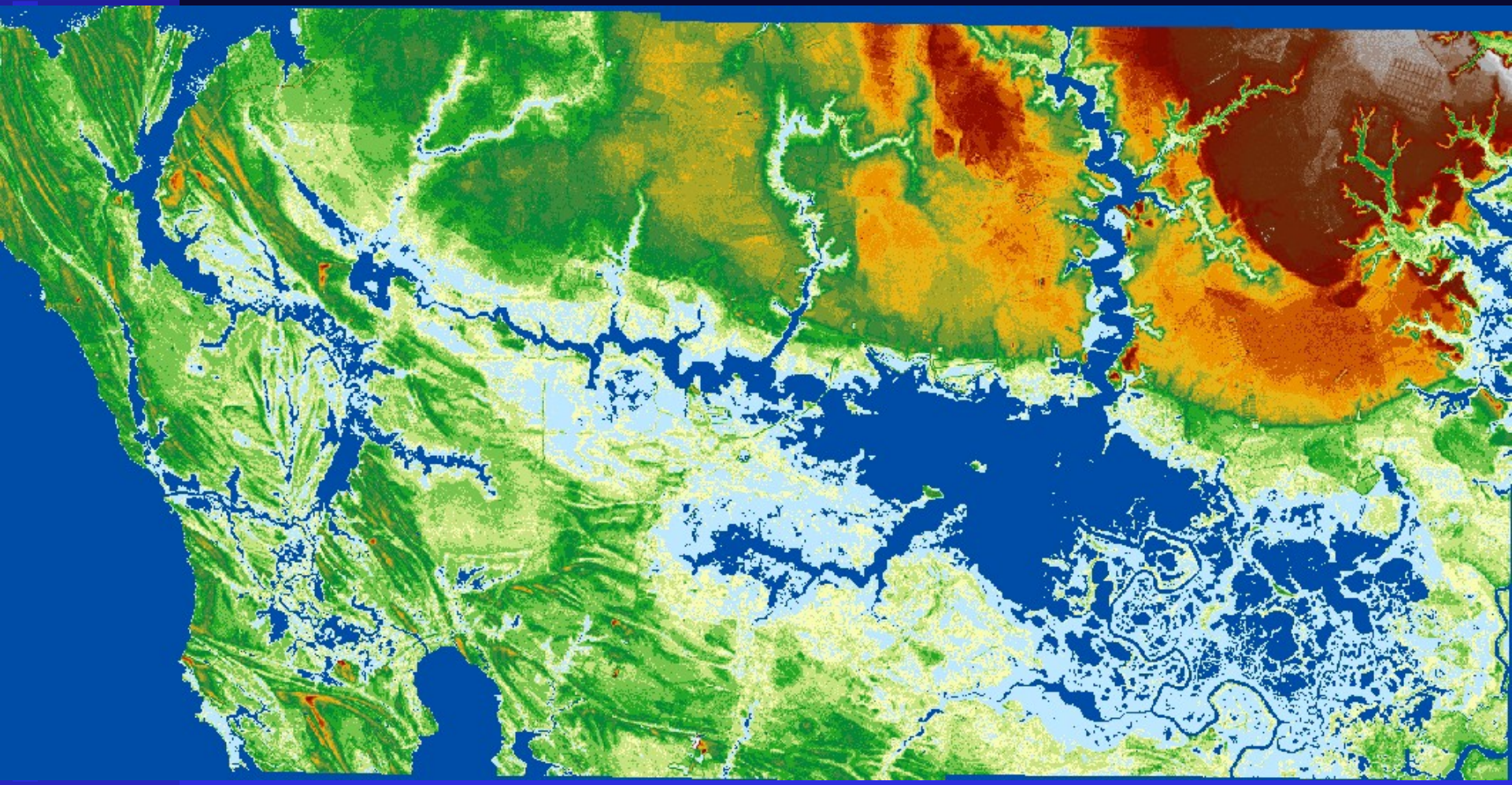


Open water

Intertidal marsh

High marsh

Blackwater National Wildlife Refuge Area, IPCC projection, average case



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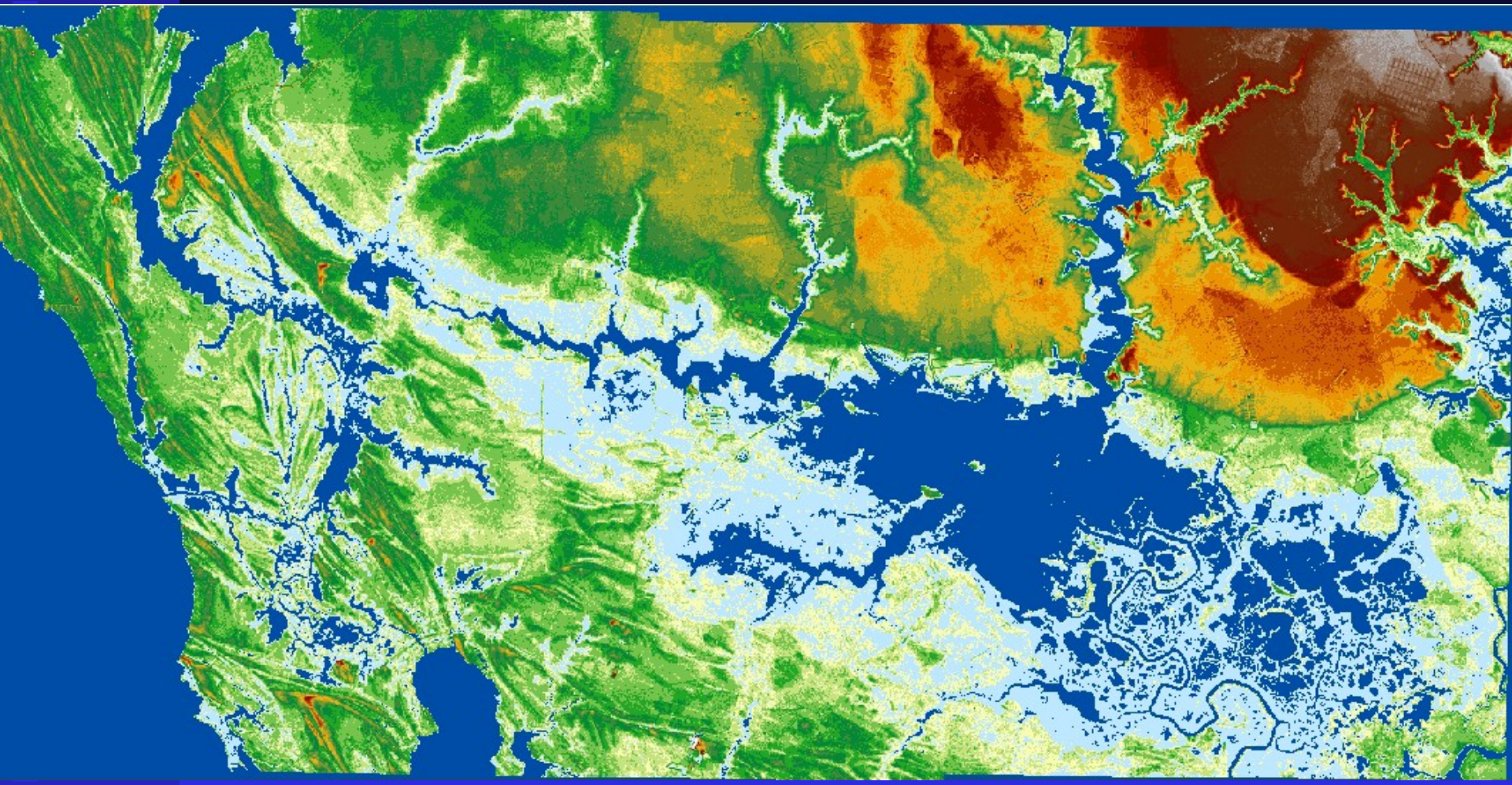

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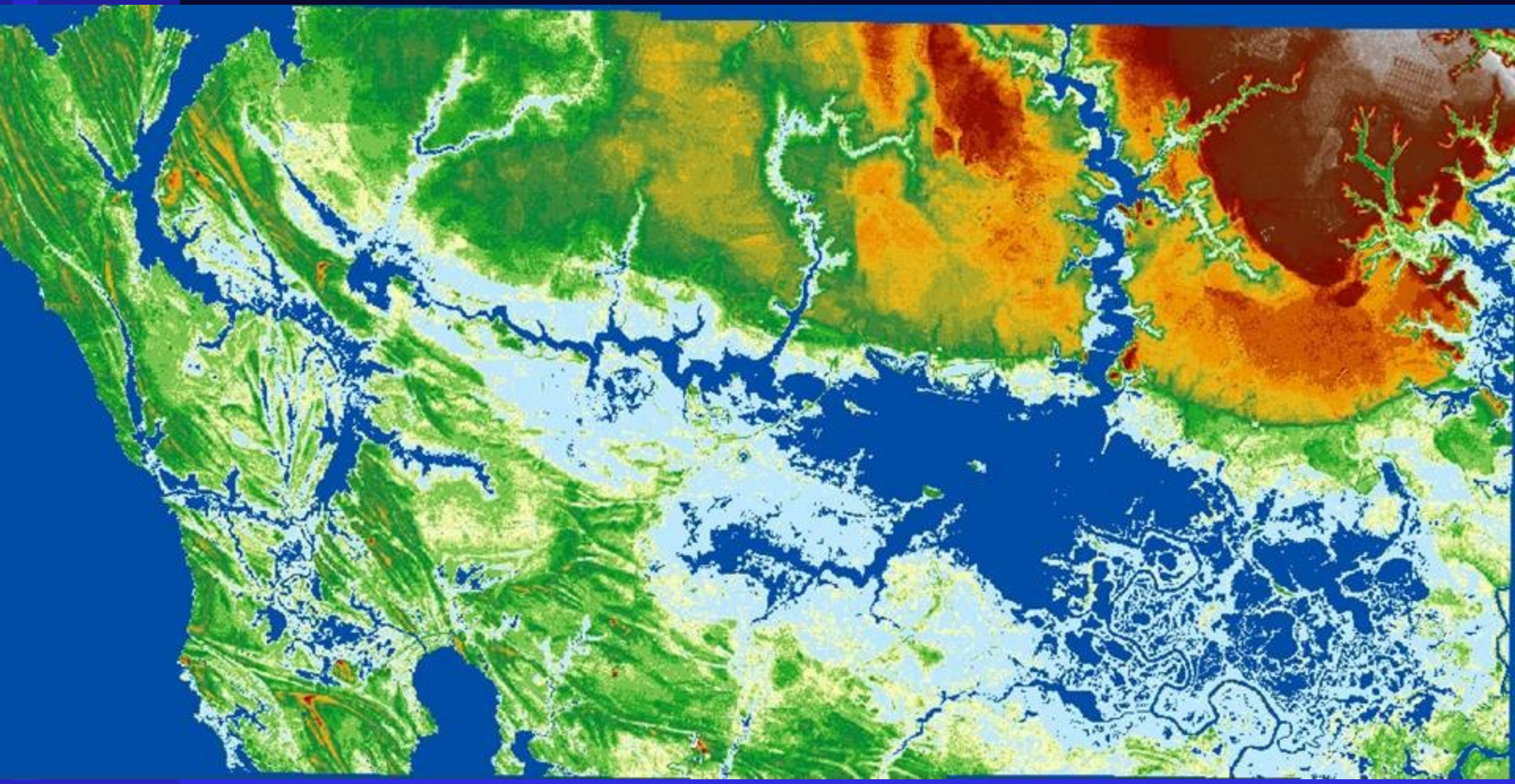

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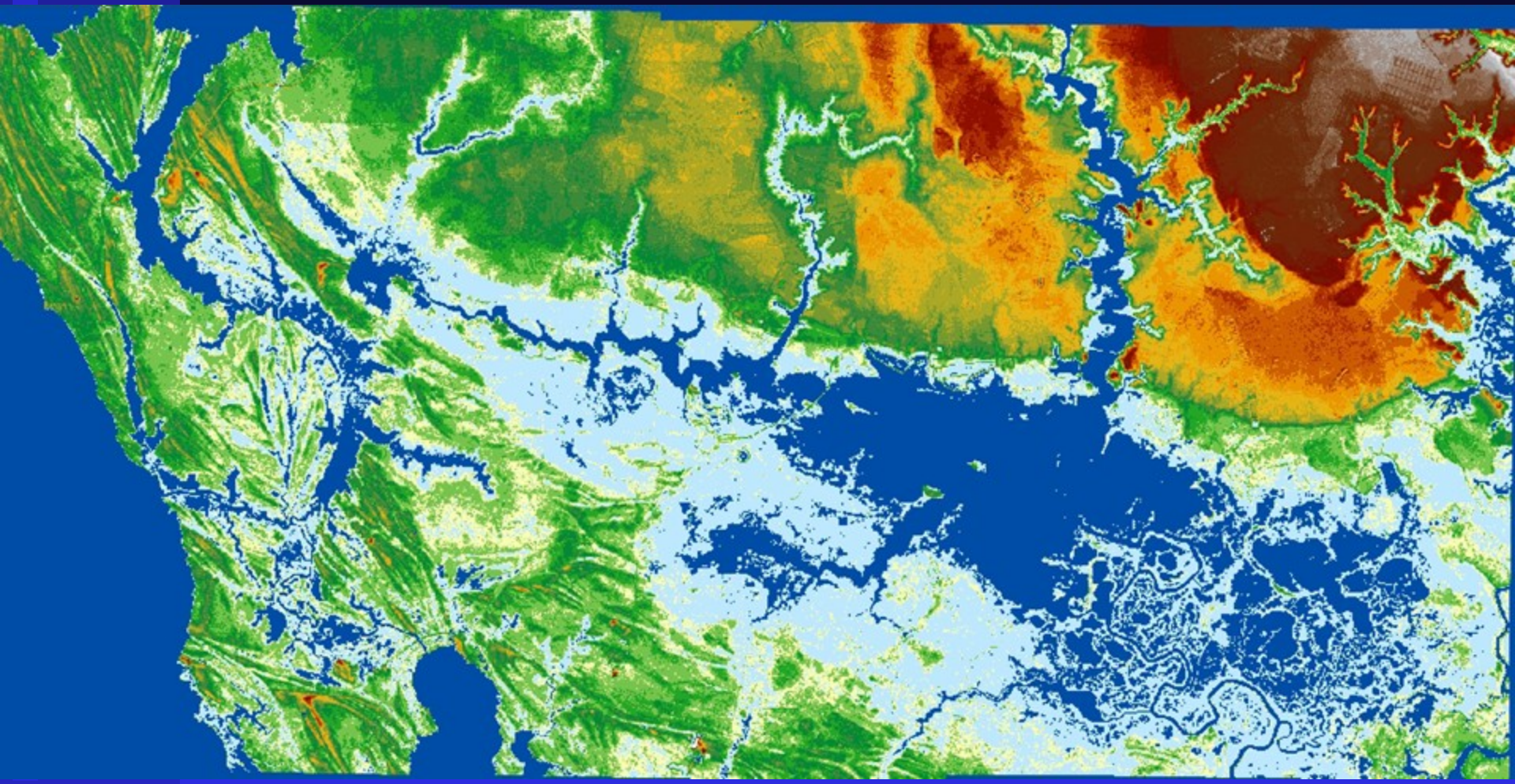

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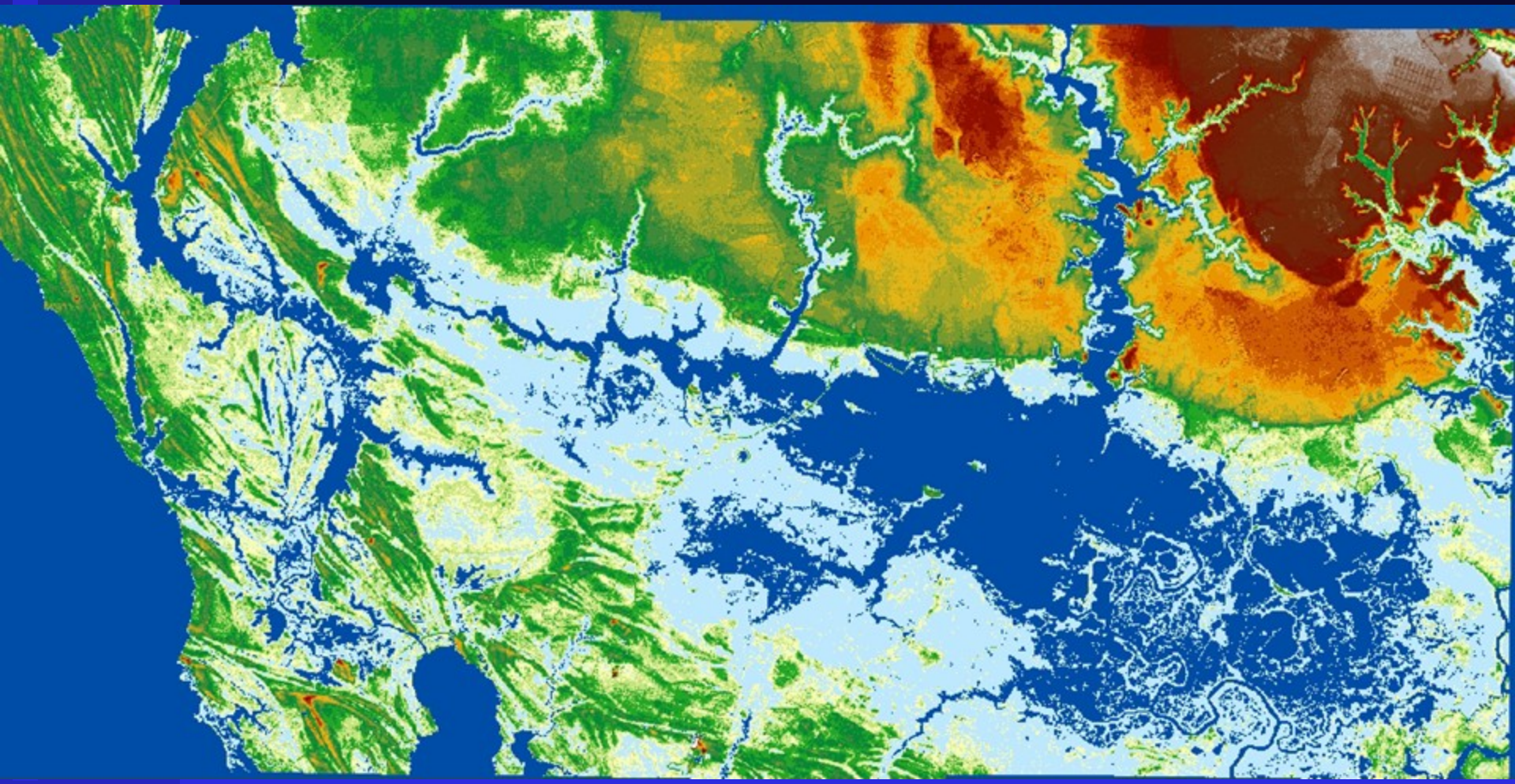
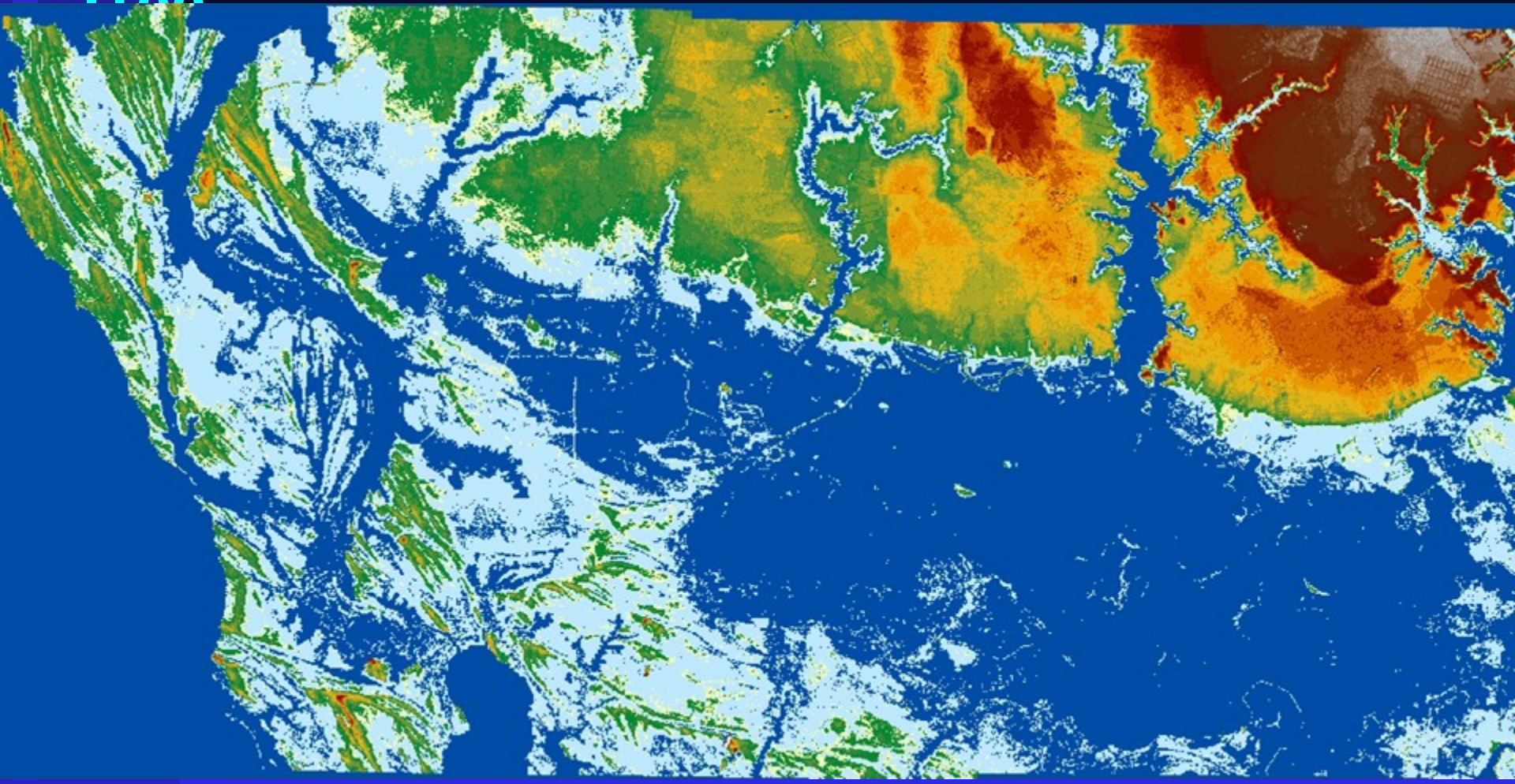
Blackwater National Wildlife Refuge Area, IPCC projection, average case



Blackwater National Wildlife Refuge Area, IPCC projection, average case scenario, 2100

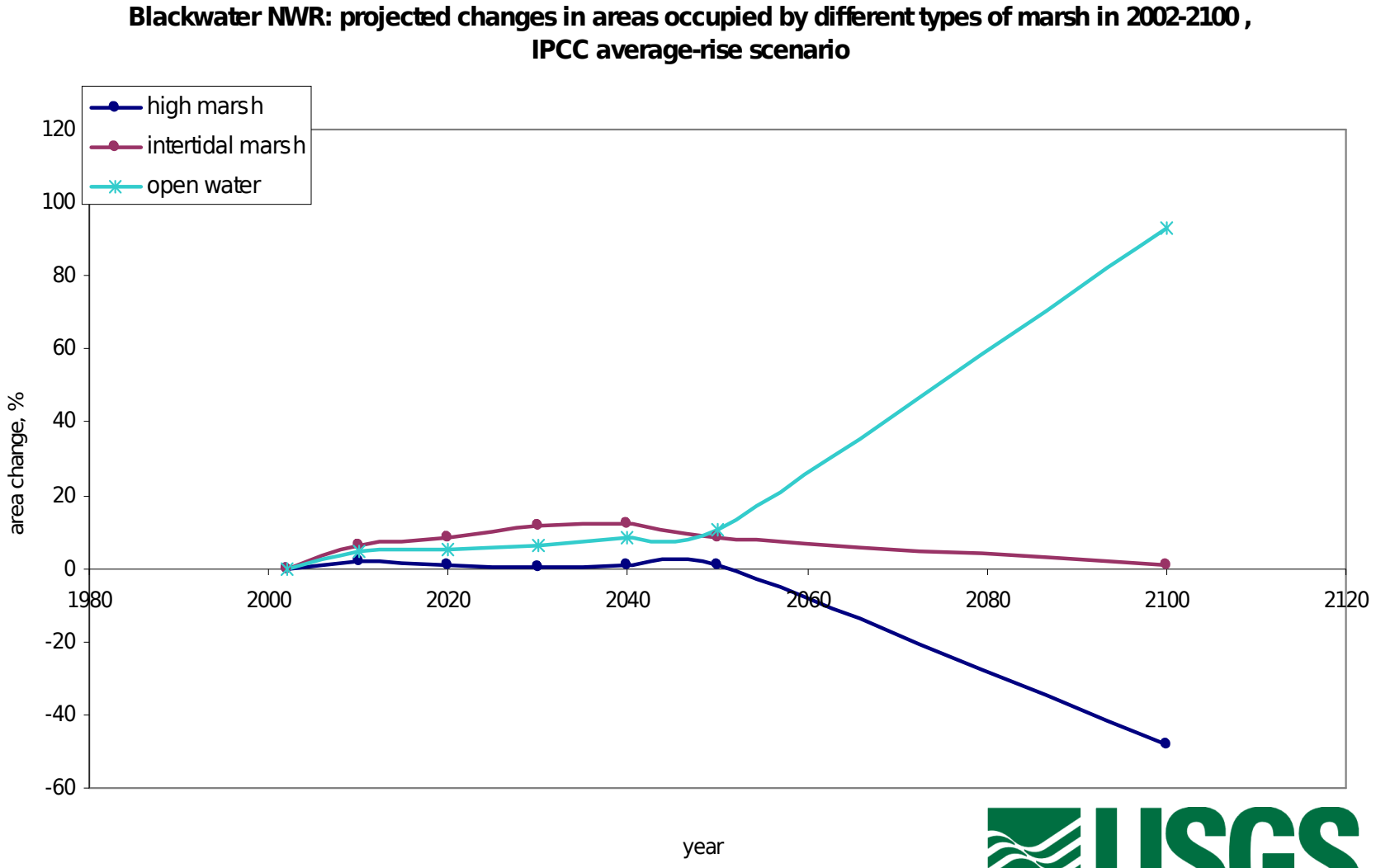


Open water

Intertidal marsh

High marsh

Marsh Changes—IPCC



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The Outcome of IPCC Scenario

- Open water area expands at a near constant rate until 2050 when the rate of change increases.
- Inter tidal marsh area increases until 2040 and begins a decline.
- High marsh area is fairly constant until 2050 when it begins a major decline.
- Both high and low marsh area decline after 2050 in this case.

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Conclusions

- The central portion of the Blackwater NWR will be progressively inundated and converted to inter tidal marsh.
- High marsh areas will shift to the western and southwestern portions of the area.
- In either scenario presented here, much of the refuge will be covered by open water by 2100.

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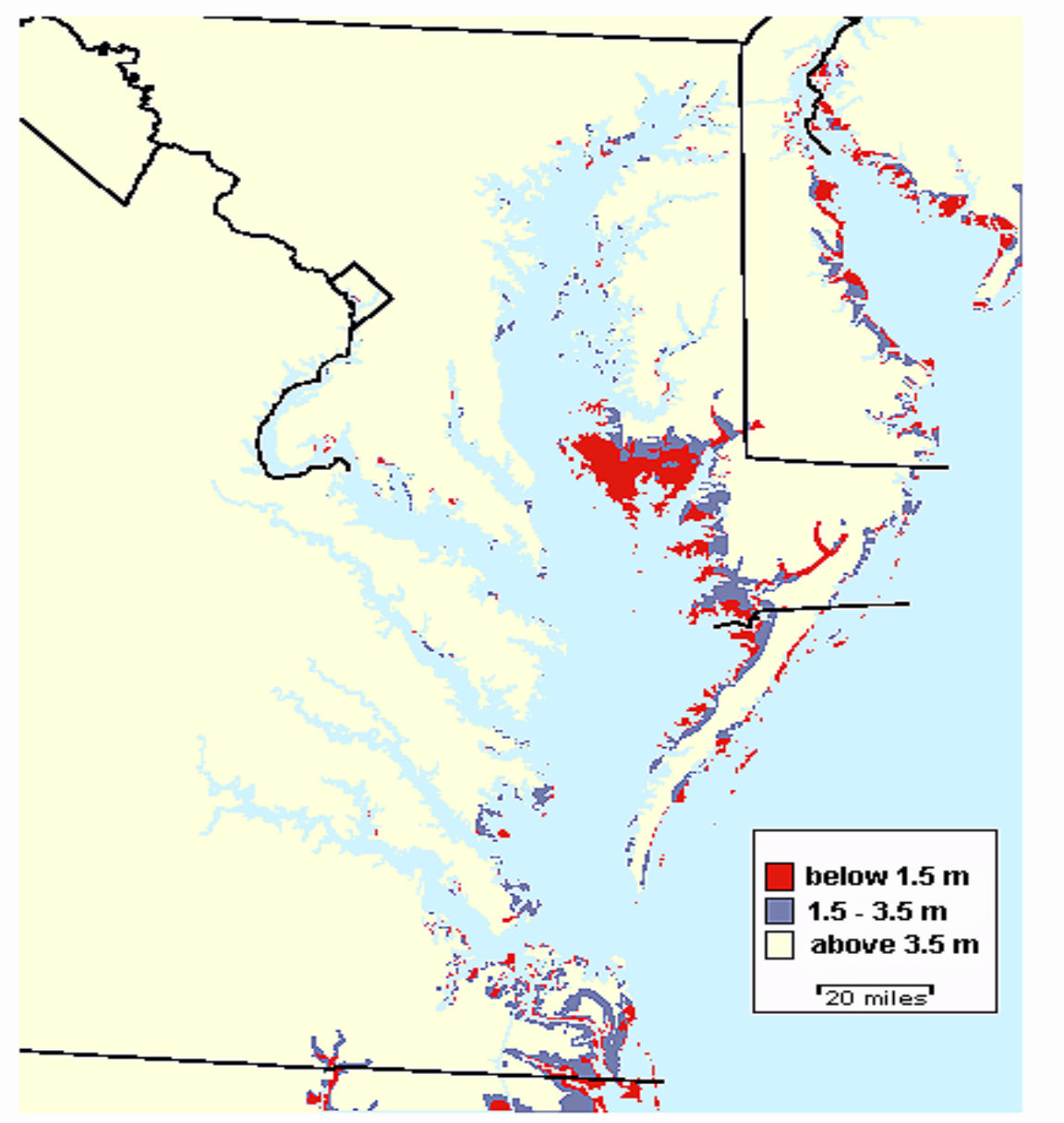
What the LIDAR doesn't say.

- The affects of coastal erosion are unknown. In short, the western shoreline will change.
- More open water leads to greater fetch and wave action across the marsh surface and to disruption of root zones and organic sediment. We don't know where this sediment will go.
- We don't know how much sediment will be eroded from the adjacent uplands and deposited in the salt marsh.

Where do we go from here?

- The Blackwater model is a prototype study for similar kinds of models to be used for wetland management planning.
- The LIDAR, coupled with detailed “on the ground” studies of individual marshes, leads to viewing these critical habitat areas as complete systems.
- Coastal refuge planning efforts need to focus beyond the boundaries of the present refuges to remain viable in a dynamically changing environment.

The EPA Inundation Mo



LIDAR does it better.

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